ILLUMINATING ENGINEERING

SEPTEMBER 1951

National Technical Conference In Abstract

THE JOURNAL OF THE ILLUMINATING ENGINEERING SOCIETY

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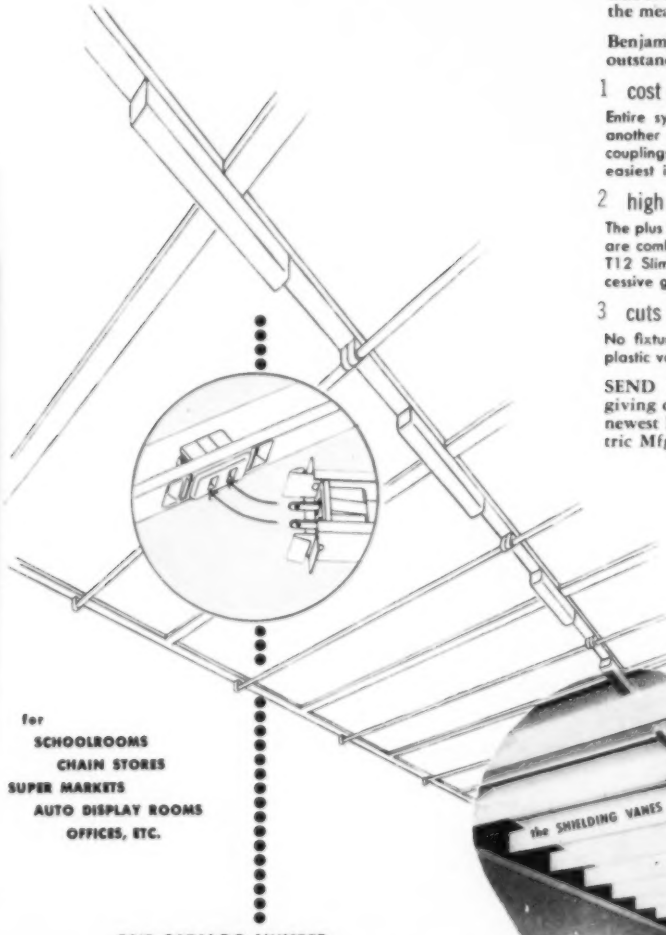

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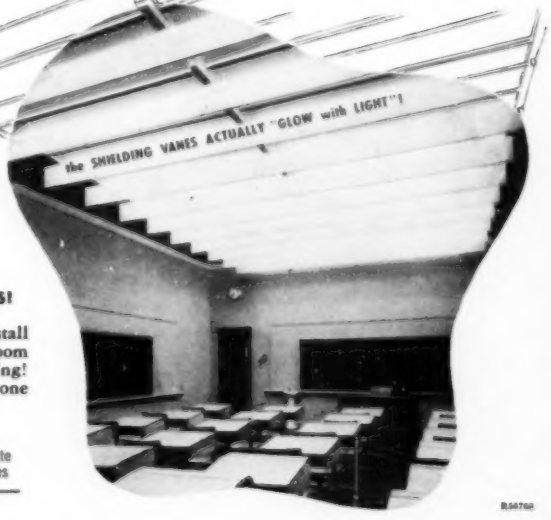

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ILLUMINATING ENGINEERING

THE JOURNAL OF THE ILLUMINATING ENGINEERING SOCIETY

SEPTEMBER
1951

Vol. XLVI
No. 9

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STATEMENTS and opinions in articles and papers in ILLUMINATING ENGINEERING are the expressions of contributors and do not necessarily represent the policies or opinions of the Society. Official Society opinions are expressed only in official committee reports specifically approved by the Council of the Illuminating Engineering Society.

Founded 1906

ILLUMINATING ENGINEERING SOCIETY

A. D. Hinckley
Executive Secretary

C. L. Crouch
Technical Director

PUBLICATION office 32d Street & Elm Avenue, Baltimore, Md.

EDITORIAL and advertising offices 1860 Broadway, New York 23, N. Y.

ILLUMINATING ENGINEERING: The Journal of the Illuminating Engineering Society. Copyright 1951 by the Illuminating Engineering Society. Published monthly in the United States of America. Entered as second-class matter at the Post Office, Baltimore, Md. Acceptance for mailing at special postage rates provided for in Section 1103 P.L.&R., Act of October 3, 1917. Authorized July 16, 1918. ¶ Subscription $10 per year plus extra postage to all countries to which second-class postage rates do not apply; single copies $1.50. ¶ Address changes must be received at I.E.S. headquarters by the first of the month to be effective with the issue of the next succeeding month.

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President's Annual Address

By **WALTER STURROCK**
President

TO A GREAT EXTENT the accomplishments of the Society are developed through a period of years under the direction of succeeding administrations, all of whom should receive their share of credit. A summary of all activities during the past year is given in the General Secretary's report by Mr. Manwaring and I will not reiterate them, but only give a few comments. Although some of the committees have had handicaps to meet, they have in general done an outstanding job in contributing technical information and in solving the operating problems of the Society. As in past years, the President again assigned the responsibility of following the technical committee activities to the Senior Vice-President and local activities to the Junior Vice-President. These have been handled in a very admirable manner by Messrs. Hibben and Strong, respectively.

In my remarks at the Pasadena Conference, I commented on several matters which I thought needed some special attention. The first one of these referred to the high number of resignations from our membership rolls. Although this year the resignations were reduced to 80% (667) of those last year, student members not included, they were far too high for the stabilization of our group. Since a great majority of these were Associate members, it was concluded that a study should be made of our membership classifications. Hence early in the year, a newly organized task committee on Advance Planning was asked to make this study. In their report the committee recommended the establishment of a new grade of membership known as a Junior Member which would come between our Student and Associate membership classifications. Action on its adoption, however, was deferred until a further recommendation could be obtained from the Committee on Professional Requisites which is making a study of our overall membership classifications and their relation to that of other engineering societies.

The second item of a year ago referred to the work of the "Coordinating Committee for Defense" whose activities are so timely that I would like to say more about them. It is a recognized fact that hostile hazards are with us all the time and, since some of the problems of defense take a long time to solve, a great deal is gained by planning through the years. Inasmuch as adequate and proper applications of light and lighting are a part of many of these problems, President Staud in 1948 appointed a Coordinating Committee for National Defense. At that time there were no appropriations adequate to staff a Research Project on lighting to facilitate night fighting. The coordinating committee, however, accepted this assignment with neither means nor personnel to find its solution. After some study a research committee was organized under the chairmanship of Dr. Bach of Tulane University who was greatly interested in the project. It was not, however, until a few months ago that funds were made available for Dr. Bach's committee project. Detailed plans had long since been prepared but their execution delayed. The corps of engineers has therefore approved the project and work is under way. The forethought in starting this activity three years ago was extremely timely and our coordinating committee is to be commended for its untiring efforts during this period. I should also

mention that through its contacts with Government Defense Agencies the coordinating committee early recognized the value of holding the 1951 National Technical Conference in Washington.

Another comment from a year ago referred to the financial situation of our Society. I hardly need to mention that rising costs and expanded activities during the past few years have considerably affected our annual expenses. As time went on the situation appeared increasingly critical. The Task Committee on Advance Planning to which I referred above was therefore asked to study the overall operation of the Society, its programs, publication activities, and its financial structure with a view of its immediate and long-range objectives. In some respects this was an emergency assignment and the committee was urged to make a progress report at the December Council meeting. In its report, the Task Committee recommended that in order for the Society to continue to serve its members as it had in the past and to build a reserve fund for security purposes, there seemed to be no course of procedure other than an increase in the annual membership dues. After careful consideration by the Council, the recommended increase in dues, to be effective on October 1st of this year, was approved for submission to the entire membership, who subsequently gave their approval for the necessary changes in Article IV, of the Constitution.

It is anticipated that the increase in dues will mean at least $10,000 in additional annual funds which, it is understood, will, insofar as needed, be used to balance the annual operating budget in which a sufficient amount will be included to maintain a minimum reserve fund to at least meet the By-Law requirements of Article VII of our Constitution. If any money is available beyond that required to meet the foregoing needs, it would then be suggested that the first two of the following recommendations be considered.

Recommendation No. 1 — That the I.E.S. become a regular contributor of at least $1000 per year to the I.E.S. Research Fund. This recommendation is made because it is believed that the most important activities of the Society are those dealing with research which (1) extends the knowledge in light and lighting applications and (2) uncovers additional fundamental facts related to light, vision and seeing. Several technical committees are continuously involved in light and lighting application research projects because they are objective in nature and can be put into practice as soon as results are obtained. On the other hand, previous to establishment of the I.E.S. Research Fund, fundamental research in an organized manner was neglected because, in general, it deals with more complex problems, some of which have little or no bearing on current lighting applications. The I.E.S. Research Fund has now been active for seven years and, although it receives its financial support principally from manufacturers and utilities in the lighting business, the Society made the first grant to it. As an expression of interest in the support of fundamental research, it is therefore recommended that at the earliest possible time the Society establish a plan for making an annual token grant to the fund.

Recommendation No. 2 — That each year an estimated amount of money be set aside so that the accrual over a three-year period will be sufficient to finance the publication and distribution of an up-to-date membership roster. There are many changes in our membership each year and even though the demand has been high for an up-to-date list, a period of nearly six years has just passed without it because there was no plan for handling the cost. A few weeks ago a new roster replaced the 1945 issue. This 1951 roster is available at $2.00 per copy and the proceeds from its sale will offset its cost. The adoption of the above recommendation will establish a program for revising the list at three-year intervals and for distributing it without charge to the membership. It is believed that this should have early consideration so that the next revised list will be made available in 1954.

I would now like to call your attention to a few matters concerning our Sections and Chapters. We have 29 Sections and 22 Chapters; the 29th Section was approved in June of this year. The Constitution permits a Chapter to become a Section at any time after three years of satisfactory operation providing its membership is not less than 50. At the present time the smaller sections often experience difficulty in annually getting a new set of officers and a Board of Managers because in many instances there are not a sufficient number of well-qualified men available to serve.

Recommendation No. 3 — In order to strengthen the organization of future Sections it would be recommended that in granting the charter the

minimum membership requirement be made 100 instead of the present 50, and that the approved organization of a Section consist of a Chairman, a Vice-Chairman, a Secretary and a Board of Managers having four members. Furthermore, I would emphasize and endorse Mr. Goddard's recommendation of a year ago that the Board of Managers remain in office for a term of two years, half being elected each year.

Among other things, each Section has one responsibility which appears to be often impractical for them to exercise, namely, that of serving on the National Board of Nominations. For example, those present at the annual meeting of this Board last February included direct representation from only 12 of the 28 Sections. Fourteen Sections were represented by proxies and 2 had no representation. Many years ago when the organization of the Board of Nominations was prescribed in our Constitution, there were only a few Sections and the Chairman of each was a member of Council. It was therefore quite convenient for the Section Chairman to attend the Nominating Committee meeting which was usually held at the time of a Council meeting. For the past eleven years the various regions of the country have been represented on the Council by the nine regional vice presidents and it is believed that if they served on the Board of Nominations, they as a group with three Past Presidents, would well represent the entire membership of the Society.

Recommendation No. 4 — It would be recommended that in order to have a more practical organization of the National Board of Nominations that Section 1, Article VI of the Constitution be changed to include the Regional Vice-Presidents, or proxies named by them, preferably from their respective regions and reference to individual Section representation be deleted.

The number of Chapters throughout the country has increased rapidly and several new ones are new in the process of development. It is very gratifying to learn about these local groups and the interest they are taking in the Society's activities. During the past year, a new Chapter was started in an entirely new area, that of Mexico City, Mexico. From the beginning of this newly-formed group there has been considerable discussion about a special reduction in annual dues to partly compensate for the low exchange value of their money. The Council fully recognizes the situation but at present does not favor a reduction in dues, because such action would still leave much to be desired for the satisfactory operation of the Chapter. Mexico is not an English-speaking country and, therefore, all the publications of our Society as sent there are considerably depreciated in value. This general situation exists in all the non-English speaking countries in the Western Hemisphere, with whom we have already given considerable thought for a closer association. In any of these countries, it is believed that with our general guidance a small group of active lighting engineers could organize their own Illuminating Engineering Society with nominal dues to meet their expenses and thereby attract for membership a large group of utility representatives, consulting engineers, architects, eye specialists and others. Such a group could hold one or more memberships in our Society in order to receive and maintain a library of our publications. Moreover, as their membership expands, they could no doubt finance the publication in their own language, of a great deal of material which we could release to them.

Recommendation No. 5 — That we discontinue to grant charters for the organization of Chapters of our Society in non-English speaking countries, but encourage them, with all the assistance possible, to organize their own independent group.

A year ago, I mentioned that the retirement pension plan for our Headquarters' staff would continue to get close attention. I am glad to report that a proposed plan was presented at the October meeting of Council and was adopted to be effective as of October 1, 1950. This retirement plan was prepared by Marsh and McLennan Insurance Agents in New York, in cooperation with our General Secretary and Finance Committee. I should also mention that as of January 1 of this year our Headquarters became eligible and were immediately included in the Social Security Plan which will provide further funds for their years of retirement.

The foregoing refers to only a few of the many problems and activities of the Society which, in general, are carried on for a period of years. I have deeply appreciated the opportunity and responsibility you have given me to direct them during the past year. I want to thank the various committees, the Headquarters' staff, and the Council for their full cooperation in carrying on our work, the results of which contribute a great deal toward better living, the conservation of human energy and the economic welfare of our country.

Some Current Goals for I.E.S.

By S. G. HIBBEN
President-Elect

FOR more than 40 years my business life has been contemporaneous with that of the Illuminating Engineering Society. It can be truthfully said that the science and art of illumination found its expanding youth and the beginning of its mature career in this same half-century.

I became a member of the I.E.S. some three years after its birth and happily it has been my privilege to know personally every President; to include among my friends the majority of the membership, and to respect each sincere aim and every inspired service of both individuals and committees of this great fraternity.

I have seen the membership grow from a few dozen to the current roster of some 5,200 Associate Members and more than 1,700 full Members; I have watched the annual consumption in this country of electric power for lighting grow during the lifetime of this Society from two billion kwh to one hundred billion kwh annually. I have seen recommended illumination levels increase from the early one or two footcandles (the first industrial lighting code) to the accepted justifiable figures of today which range from 30 to some 50 footcandles for ordinary visual tasks and to ten times this intensity for the more difficult tasks. I have watched the customer's lighting dollar purchase for him some fifty-fold its lighting value of 1907. But these are transient values — milestones — not termini on the long road to perfection!

Because of the dedication of my life's major work to the advancement of the cause of producing and applying radiant energy, and because of my personal pride in our lighting progress, and in being numbered among this host of inspired Society Members, may I be forgiven, or at least hearkened to sympathetically, if I briefly outline some of the approaches to — or the methods of attainment to — some of the goals that seem currently desirable?

(1) It would seem that our present membership does not include many groups that would profit from our available services, nor individuals who would benefit themselves and their clients through a fuller understanding of vision and of the better and best practices of lighting. It appears reasonable to *look towards a total membership of some 10,000 individuals.*

One way to facilitate our growth is to *establish more Chapters, i.e.* provide more centers where lighting activities will be able to induce membership and hold members together. There are far too many bare spots where we have no Chapters and no local activities and consequently very few individual members. I would urge Council to study every reasonable means to encourage *student membership* among the undergraduates of approved colleges and in line with our global policies to consider some reasonable *expansion of our membership outside of continental North America* through an easement of the penalty brought about by our present differences of exchange between American dollars and the foreign currencies.

We should search for some means to cement a *closer bond with electrical contractors,* since they are responsible for so much of the "bread-and-butter" lighting practice.

(2) I urge a wider base for *Sustaining Memberships.* In the last three years, Sustaining Membership income has increased only some

Substance of an Address presented by the President-Elect of the Illuminating Engineering Society, before the National Technical Conference of I.E.S., Washington, D. C., August 27-30, 1951.

$400. The number of Sustaining Members has been static for several years, this in spite of the continuing rapid growth of lighting business and kilowatt-hour sales. In brief, our Sustaining Membership activities must be vigorously continued, perhaps guided by a formula that places this cooperation fairly among all operating utility companies in proportion to their number of meters or their adjusted volume of business, or which (even if a reasonable fraction of those profiting from our Society would contribute mildly to its operation), should result in an annual income of some $75,000 or on the order of *double the present sum!*

(3) We should gradually build and *strengthen a dollar reserve* in quickly negotiable condition as a guarantee to protect pensions, to insure the continuation of research projects and to carry on the dissemination of knowledge through possible lean business years.

(4) High on the list in liquidating a heavy investment in printed material, is to energize rapidly and widely the *sale of the new I.E.S. Handbook*. This is a weapon against darkness that is of no value until it is in the hands of the owner or user.

(5) Organization-wise I feel that the *Headquarters setup and staff is satisfactory* — in fact, one in which we can take great pride. The new Headquarters and the better facilities should carry us along for quite a few years to come, and we may expect 1860 Broadway, New York to be our home address until such a time as we may eventually move into the electrical industry's own Headquarters building, should that dream ever crystallize. We seem to find no justifiable reason now to change the date of our fiscal year nor to disrupt any of our present practices as to our types of Council Meetings, Regional Conferences or Annual Conventions.

(6) I would, however, urge everyone to join with our Regional Vice Presidents in *strengthening our Regional Conferences* so that a higher percentage of our membership can meet with and participate in lighting papers and discussions, with a minimum amount of traveling expense and time. In this connection and for some relief to the Regional Vice Presidents' burdens, it would seem advisable to crystallize as soon as possible the *geographical limits of the two proposed new regions* in the United States and to later consider the idea of an additional Regional Vice President to direct operations of all of our I.E.S. activities outside of the United States and Canada. This officer would be our liaison representative on the International Commission on Illumination (C.I.E.) — a world-wide group of great influence.

Allied with the matter of Regional Conferences is my recommendation that Council also study the feasibility of holding *two general Technical Conferences annually*, either one in the fall and another in the spring or else one in the East and one in the West. The cumbersome size and volume of papers of a single annual Convention is one factor, others being the problems of transportation costs for delegates, and the load on the Headquarters staff.

(7) The work of our *Technical Committees* seems *more vitally important* with each passing month. However excellent such Committee work may be, we must not forget that one major objective is to get the material in print for widespread distribution. Reports of certain Committees are especially important just now in connection with the defense effort. These are the times when production, safety and better methods of doing more (all influenced by lighting) are uppermost in the minds of the public. Several *new lighting study projects* in Industry seem logical among which might be added the operations in the plastic industry; in the photochemical processes; in the growth and treatment of plants and flora in general; perhaps in some of the work of our national defense.

These and other business and financial matters will, I am sure, receive the most careful consideration by your officers, always considering the importance of acceptance by your membership. Running unbroken throughout the pattern of the future months is the one fundamental obligation to *provide mankind with better see-abiltiy!* No work of our Society seems more basically important than the continuation and re-emphasis of the *studies of human vision*. (Keeping in mind our high engineering ethics, we must work for more factual knowledge!)

The Society we must serve is personified by an individual whom we all know, and whom I choose to call Mr. Average Man. He is about 5 feet 8½" tall, weighing 155 pounds and he lives to be about 58 years old. His average occupational age is between 35 and 40 years. He sleeps approximately one-third of his lifetime, or 19 years and he must see well enough during his actual total working time of some 20 years so that he may accumulate sufficient wealth to enjoy the rest and play of his

(Continued on page 487)

Abstracts . . .

from the General Technical Sessions of the I.E.S. 1951 National Technical Conference

The Cost of Seeing a Critical Industrial Task

Willard Allphin

THIS PAPER carries further the work previously reported on muscle action potentials, (published on page 188 of the April 1951 issue, ILLUMINATING ENGINEERING) and applies the measurement technique to an actual task in industry. The task was the forming of a shaped bend in a "cat whisker" for a silicon diode detector. The wire, 0.002" in diameter, had to be seen clearly at three stages during the process.

Interpretation of the tension level readings was made in terms of slopes of the curves rather than absolute values. That is, when the subject was relaxed or when working under a high illumination level the tension level slightly declined. When working under low levels of illumination the tension level slowly increased.

Plotting the slopes of these curves in terms of the slope of the curve representing the relaxed state gave the results shown in the accompanying illustration. An average line has been drawn through the points, but the points are too scattered to give the average an exact significance. However, in lieu of more complete information, it can be predicted that illumination of 1200 footcandles could be used to advantage in performing the task.

Incidental measurements of production rate carried on at the same time showed an increase of 17 per cent in going from 20 to 100 footcandles.

Author: Sylvania Electric Products, Inc., Ipswich, Mass.

(Abstract of I.E.S. 1951 Conference Paper No. 1)

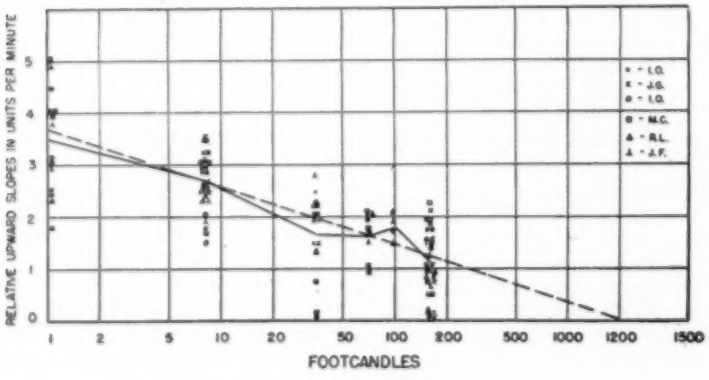


Figure 1. Slopes of tension level traces, relative to slope for relaxed state.

A Method of Calculating Direct Illumination From Linear Sources

R. G. McPhail

THE PROPOSED method of calculating direct illumination from long linear sources such as continuous rows of fluorescent luminaires seeks to reduce the labor involved in such calculations and at the same time increase their accuracy. This is accomplished by precalculating most of the equation for point by point calculation of illumination and basing the precalculated functions not on a mathematical prototype, but on the measured candlepower distribution of the actual luminaire.

Preferably the precalculated functions should be made part of the photometric data in some form similar to Chart 1. They are numerical ratios and are used in much the same manner as the common trigonometric functions. For convenience they have been named "*Los*" and "*Sol*." Both are given in terms of L/S, the ratio of the length of the light strip to the distance from the strip to the point.

Los applies to illumination on planes parallel to the light strip; *sol* applies to illumination on planes perpendicular to the light strip. For longitudinally tilted planes, both functions must be used. In every case *los* and *sol* must be multiplied by I, the perpendicular candlepower in the direction of the point and divided by S, the distance from the point to the source. For instance, Fig. 1 shows the formula for calculating illumination on a point directly beneath the source. It will be noted that two calculations are used, one for the part of the light strip extending to one side of the point, the other for the part extending to the other side. Similar formulae for calculating illumination on points in

Author: Holophane Company, Newark, Ohio.

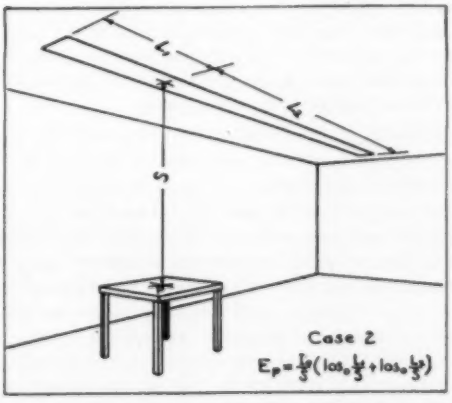
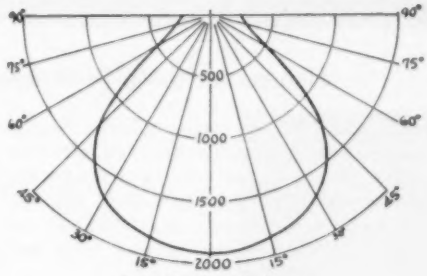


Figure 1. Typical example of point by point calculation by this method.



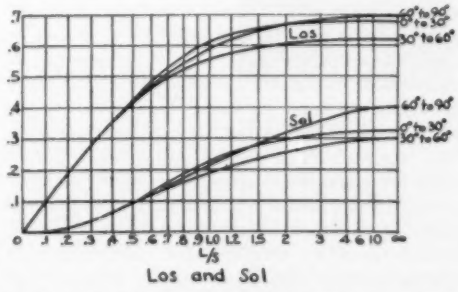


Chart 1. *Los, Sol* and crosswise distribution curves for a 4-lamp, 4-foot commercial fluorescent luminaire with prismatic brightness control both crosswise and lengthwise.

other positions have been devised and are explained in the paper. The same formulae can be used for approximate calculation of illumination from discontinuous rows of incandescent sources and to find the quantity of light falling on a strip from a point source. Formulae using *los* and *sol* have also been devised for finding the quantity of light falling on a strip from a linear source.

Los and *sol* are calculated from the lengthwise distribution curves of the fixture by multiplying the measured candlepower at various angles by a series of constants and adding progressively. If not available as part of the photometric data, they can be calculated by the installation engineer. If photometric data on a particular fixture are unavailable or inadequate, curves for a similar fixture will generally give satisfactory results.

The paper contains a detailed description of the method of calculating *los* and *sol* and a table of *los* and *sol* constants. In it will also be found the mathematical derivation of all formulae.

(Abstract of I.E.S. 1951 Conference Paper No. 16)

Left to right:

D. D. Hinman
R. L. Keiffer
C. E. Strecker

Fluorescent Lamp Performance on Sequence-Start Ballasts

OPERATION of two lamps in series from a ballast having voltage sufficient to start only one lamp, by a sequence starting arrangement, allows a saving in ballast weight, loss, size, and cost. However, lamp starting characteristics must be taken into consideration or poor lamp performance will result.

By whatever means a hot-cathode lamp is started, two transitions must take place; first, the gas in the lamp must be sufficiently ionized to conduct current; second, the fall in potential at the cathode, commonly called cathode drop, must be decreased from its initial high value to the low value attained during normal lamp operation. The sequence-start ballasts are little different from the standard ballasts in producing the first transition in which a minimum peak voltage is the main requirement. With standard ballasts the second transition usually takes place in only a few cycles on a 60-cycle a-c supply, whereas with the sequence start ballasts, because of lower current available to the lamps, this transition requires up to several seconds. Even at the normal currents available from standard instant-start ballasts, an appreciable amount of damage occurs during starting as demonstrated in the well known effect of frequent starting in reducing lamp life. When the current available to the lamp during the second transition is low, the cathode drop remains high for a longer time and rapid cathode disintegration takes place.

Because of the inherent advantages of the sequence start circuits, designers of these ballasts should be encouraged to continue its development, but ballast specifications should be drawn up to insure satisfactory lamp performance. It is difficult and somewhat impractical to specify ballast characteristics by speed of lamp starting because of large variations between lamps and even between successive starts of an individual lamp. The volt-ampere characteristic of a ballast gives a direct indication of the current which can be supplied to a lamp during its various starting stages. Present specifications determine the open

Authors: Lamp Department, General Electric Co., Cleveland, Ohio, and Apparatus Department, General Electric Co., Fort Wayne, Indiana.

TABLE I.—Proposed Values of Current and Resistor to Determine Acceptable Starting Characteristics of Fluorescent-Lamp Ballasts. Ballasts must furnish the stated minimum current to the specified resistor at 90 per cent of rated supply volts.

Lamp Size	Lamp Operating Current Milliamperes	Test Resistor Ohms	Minimum Milliamperes
42"T6	120	3000	75
	200	3000	90
	300	3000	100
64"T6	120	4000	75
72"T8	200	4000	90
	300	4000	100
96"T8	120	5000	75
	200	5000	90
	300	5000	100
48"T12	425	2750	100
72"T12	425	3400	100
96"T12	425	4000	100

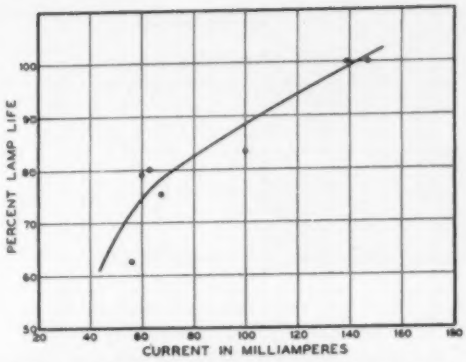


Figure 1. Life of the 48T12 and 96T12 lamps *vs* the current supplied by the ballast to resistors of 2750 and 4000 ohms respectively.

circuit voltage which is one point on this characteristic, and, one additional point would fairly well define it. A very practical choice of this point is the voltage and current supplied to a resistor chosen to represent the lamp impedance when the cathode drop is at its highest value. Examination of life test data, as shown in Fig. 1, and analysis of lamp starting characteristics on lead-lag ballasts confirms that use of the current and resistor values of Table I would form an acceptable basis for ballast specification. The voltamperes available from a sequence start ballast will change depending upon whether the other lamp position is open-circuited or loaded with a lamp. It is intended that the currents listed in Table I shall be furnished both with and without a lamp in the other position. The suggested values of current and resistance will result in ballast savings and lower costs of light over conventional systems with only a small reduction in lamp life. *(Abstract of I.E.S. 1951 Conference Paper No. 14)*

Modern Concepts Of Lighting Maintenance

Fred J. Vorlander

THE THREE most important factors in lighting maintenance are: lamp blackening, dust accumulation on lamps and fixtures, and lack of planned maintenance schedules. The consumer can do little about the first two factors, but the other is his problem.

Lack of consumer interest in proper maintenance is largely the fault of the lighting industry in not providing specific information which can be easily and profitably applied with reasonable accuracy to most any lighting system by non-technical as well as by technical personnel.

One of several activities which will simplify maintenance yet usually result in a profit to the consumer, is the planned group replacement of lamps, wherein tangible profit results from the saving in time required to change lamps in groups rather than individually. Extensive studies show that lamp changing time is reduced from an average of 20 minutes for individual changes to three minutes for group replacements for either incan-

Author: Champion Lamp Works, Lynn, Mass.

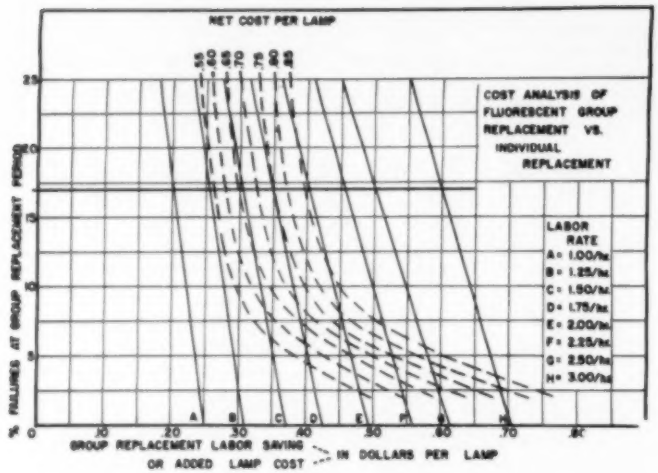


Figure 1.

descent or fluorescent lamps. Today's manpower shortage makes this a very timely subject.

Lack of major interest in group replacement in the past, other than for street lighting, has been due to the lack of specific data sufficiently flexible and simple as to be easily applied. This new group replacement plan provides the needed material in the two charts shown. These charts are based on two formulae which provide complete flexibility to compensate for wide variations in lamp changing labor time, labor rates including overhead, lamp net cost and the time when lamps will be changed.

The economic justification can be determined by merely checking the horizontal distance between the labor saving curve and the lamp cost curve of the applicable chart. It is no longer necessary to guess when lamps should be changed.

The intangible values often outweigh the tangible values and they, too, are very important, particularly at this time when production efficiency and labor saving are so important. Several of these intangibles are as follows: Increased illumination, the effect of increased illumination, improved lighting quality, manpower saving and better maintenance scheduling.

(Abstract of I.E.S. 1951 Conference Paper No. 39)

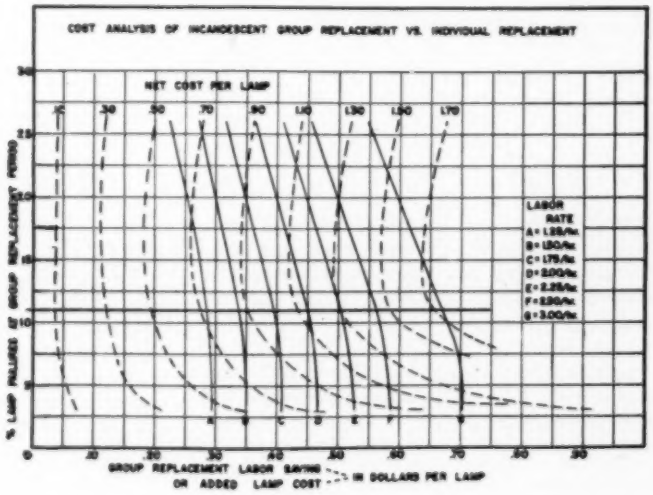

COST ANALYSIS OF INCANDESCENT GROUP REPLACEMENT VS. INDIVIDUAL REPLACEMENT
NET COST PER LAMP
LABOR RATE
% LAMP FAILURES AT GROUP REPLACEMENT PERIOD
GROUP REPLACEMENT LABOR SAVING OR ADDED LAMP COST IN DOLLARS PER LAMP

Figure 2.

Photometric Testing
By Fluorescent Fixture Manufacturers

E. D. Tillson

THE AUTHOR believes it is common sense and common practice for manufacturers to test their products during and after processing. Thus the food manufacturers provides himself with test kitchens. The manufacturer of insulators conducts breakdown and leakage tests, the paint people develop their own weathering tests, and so on. How else can they be posted on the quality of their products?

But in the lighting equipment field the great majority of fixture manufacturers do not have facilities to test their products and, hence, are at a disadvantage.

It is true that there are available a few—a very few—commercial test agencies, and excellent ones. However, the agencies are, with respect to many fixture manufacturers, located at a distance, and in such cases not too well adapted to perform running tests during the development of a new product, or routine tests on lines regularly produced. It is therefore believed that, *in addition to these facilities* the fixture manufacturer should have the means, within his own establishment, to check the performance of the things he manufactures.

One object of the paper is to prove that the cash outlay is very moderate, that much of the apparatus can be made up by the owner, and that the personnel and floor space problems are not as serious as they might at first appear. Another object of the paper is to show in detail how to go about it.

Today it is fundamental to know the candlepower, flux and brightness distribution, and in the case of recessed equipment, temperature rise.

If the manufacturer has the proper test facilities he can determine all the above from models in the course of a day. Test results, when plotted, show where the models are to be revised. Additional models are built and the procedure repeated—and so on. Finally the manufacturer is in a position to have his test results checked by

Author: Consulting Engineer, Lighting Products, Inc., Highland Park, Illinois.

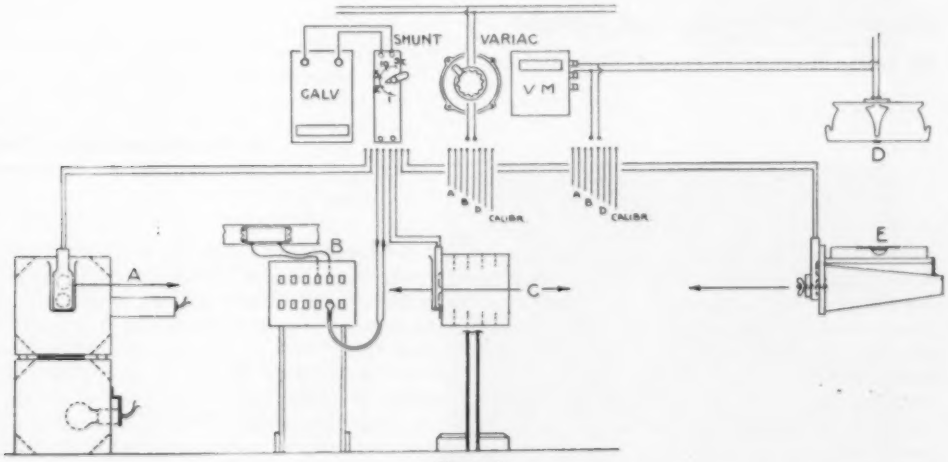


Figure 1.

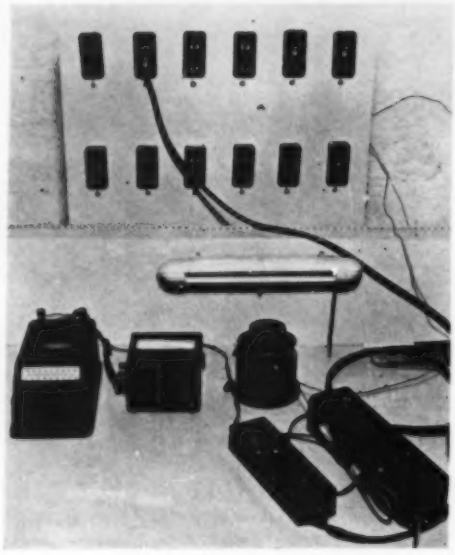


Figure 2.

an outside agency, and for this purpose fabricates and submits with confidence a finished sample, constructed exactly as the item will be marketed.

As opposed to expensive instrument outlay, there are satisfactory test procedures whereby a few well chosen instruments can be used interchangeably for a variety of purposes. For example in the plan here outlined, the same galvanometer, costing $60.00, is used to determine

1. candlepower distribution,
2. brightness values,
3. reflectance and transmittance,
4. temperature rise.

Similarly with the barrier layer cells, voltmeter, variac, shunts, etc. In the plan submitted by the author, all have multiple uses (see Figs. 1 and 2).

With these instruments as a nucleus, it is possible for the fixture manufacturer to build his own rotator, photometer-head, brightness meter, etc. using materials ordinarily available in a fixture factory. The paper illustrates these items in a general way. Working drawings have been made, but due to their size could not be included The originals have therefore been deposited with Society Headquarters Office and sets of prints are available at a nominal price.

In the paper, minimum of equipment and expense is stressed. Check tests with laboratories having full complements of equipment show candlepower, zonal lumens and efficiencies to be in agreement within 3 to 5 per cent.

Sets of seven working drawings in sizes 14½ by 22 inches are available from I.E.S. headquarters for $1.00 per set. Address requests to Publications Office, Illuminating Engineering Society, 1860 Broadway, New York 23, N. Y.

(Abstract of I.E.S. 1951 Conference Paper No. 37)

Object-Color Changes from Daylight To Incandescent Filament Illumination

By Harry Helson, Deane B. Judd and Martha Warren

IF TWO identical colored samples are placed in color boxes illuminated with light sources having different spectral qualities (for example, an incandescent filament lamp and a source emitting simulated daylight) and the observer momentarily views first one sample and then the other, there is considerable difference in the appearance of the samples. However, if the observer, after having been in an area lighted with daylight quality for a period of time makes a mental note of the appearance of the sample and then enters a room lighted with incandescent filament sources and after a period of time is again shown the sample, the difference in appearance of the sample is much less marked; that is, the sample tends to appear the same regardless of the light source, provided the eye is allowed to become adapted

Authors: Harry Helsen, University of Texas; Deane B. Judd, National Bureau of Standards; Martha H. Warren, Brooklyn College. Author: Holophane Company, Newark, Ohio.

to the color quality of the source. This is known as color constancy. But the ability of the eye to adapt itself to sources having different color qualities is not complete. Also, the background color has considerable influence. This report presents formulae that make it possible to predict the color changes that will be perceived as the color adapted eye views samples under sources of different quality.

To solve this problem six observers were selected and trained to report in terms of the Munsell color system the hue, lightness and saturation under light from the north sky. When the observers became skilled the observations were carried on in a light-tight booth illuminated by artificial daylight (source C, Macbeth 6700K) and then under incandescent filament lamps (Source A, 2854K), using a black, white, and gray background for both sources. The observers' eyes were allowed to become adapted to the illumination in each case.

The hues and saturations of the samples as estimated by the observers were compared with the hues and saturations calculated for the samples according to formulae embodying a simplified Young-Helmholtz theory of the adaptation of the eye under source A. This theory has predicted fairly well the changes in hue in passing from artificial daylight to incandescent filament light (source C to A). The simplified theory employed here does not take into account background effects which may be quite large when backgrounds of either very high or very low reflectance are present. For the background of intermediate reflectance (gray) used in this study the theory seems to supply a useful and statistically reliable first approximation to the observed data.

(Abstract of I.E.S. 1951 Conference Paper No. 40)

Floodlights at Work

F. R. Jeffrey

THE INCREASING use of floodlighting to permit twenty-four-hour operation of construction, mining, and manufacturing operations, has parelleled the activity in the sports, recreational, and building floodlighting field.

However, there has been little published technical data on the subject, and our I.E.S. Handbook is similarly barren on this important subject. This paper is intended to highlight some of the wide variety of problems encountered, and not an attempt to cover the whole field and provide the answers.

A very considerable amount of study and investigation will be required to set up footcandle intensity tables, and such tables, if available, would be most helpful. It is my hope that this paper will stimulate such studies.

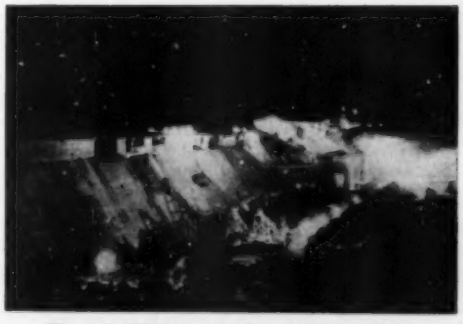


Figure 1. Night construction at Des Joachims.

Author: Crouse-Hinds Co. of Canada, Ltd., Toronto, Ont.

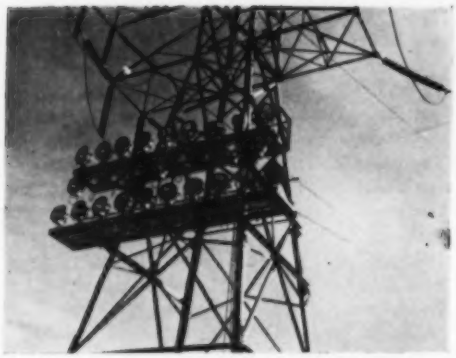


Figure 2. Final mounting of twenty-eight 1500-watt floodlights.

Light intensities varying from one to ten footcandles have been used for varying types of night construction, but authoritative technical data on the subject would be most helpful to all concerned with such activities.

The problem of floodlighting work areas is, of course, to place sufficient light where it is wanted, with a minimum amount of glare in the worker's eyes, and at a minimum cost.

Construction jobs often require that floodlights be moved as work progresses, and repair or emergency jobs require light, often in a matter of minutes.

Scotch thrift and foresight were both exemplified in the two pictures following. The Power House and Dam at Des Joachims (pronounced De Swisha) on the Ottawa River, north of Ottawa. The Power House and Switches were on the down-stream face of the dam, and required lighting for night operation and emergencies; also, the very large switching area on the near bank must be lighted. The floodlights were ordered in time so they could be used for night construction work.

The switching area, 600′ x 322′, will be lighted from six towers per side—55′ high—using forty-four 1000-watt floodlights, which were also used for construction floodlighting. The light intensity will be approximately 1 footcandle on this area.

"Floodlights at Work" are materially contributing to the building of Canada, and I am sure that the same holds true in the U.S.A.

Surely this branch of Lighting Industry deserves its place in the Technical Journal and the Lighting Handbook, and if we each make our contribution, there will soon be available a broad background of Technical Data on the subject.

(Abstract of I.E.S. 1951 Conference Paper No. 12)

Noise in Gaseous Discharge Lamps

J. Warren Culp

FLUORESCENT lamps as noise sources are of interest to the illuminating engineer because of their frequent use near radios and because of the possibility of controlling their radiation to the receiver. Radiation from the wiring of the lamp can be suppressed by well known methods. Noise radiation from the tube itself cannot be prevented so easily, and it is desirable to learn the nature and source of this noise with a view toward its eventual elimination. This paper describes an investigation of the fundamental mechanisms of noise generation in fluorescent lamps.

Four types of noise are distinguished. These are termed reignition noise, hollow-cathode noise, anode noise, and starting noise. Reignition noise is usually the most conspicuous; it can be seen in the oscillogram of Fig. 1 as a large, grassy pulse occurring twice in each lamp cycle. This type of

Author: Physics Laboratories, Sylvania Electric Products, Inc., Bayside, N. Y.

noise is generated near the cathode during the portion of the cycle when the arc is reigniting, just after the alternating current has reversed. At that time an ion sheath is building up in front of the cathode, and it is shown that the radiated noise is the result of rapid changes in the space-charge distribution. The noise consists of a somewhat irregular oscillation having a frequency about 200 kc/sec, and a receiver tuned in the broadcast band responds to harmonics of the oscillation.

Hollow-cathode noise is a smooth oscillation which occasionally results from formation of the cathode spot at the location of a cavity in the filament coating. Anode noise consists of a series of low-frequency pulses (visible in Fig. 1) that are associated with the characteristic fluctuations in the voltage drop at the anode. These types of noise are similarly attributed to space charge fluctuations. Starting noise is generated in the arc which shunts the filament when the discharge is first fired; it is a combination of reignition and anode noise.

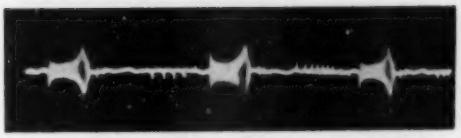


Figure 1. Output of a receiver with a fluorescent lamp operating near the antenna, as displayed on an oscilloscope.

(Abstract of I.E.S. 1951 Conference Paper No. 5)

Domina Eberle Spencer

Vincent J. Stakutis

Howard F. Kingsbury

Robert W. McKinley

Glass Block Fenestration and the Interflection Method

AVAILABLE methods of predicting daylight distribution are empirical and provide no convenient means for predicting brightness distribution throughout the visual surround. Also, most previous work has assumed a uniform sky and no interflections. Methods developed for calculating direct illumination from perfectly diffuse rectangular windows are not applicable to most glass block panels.

Hoping to obtain a simple, general method that would be applicable to all types of glass block, Pittsburgh Corning believed it worthwhile to investigate the utility of the interflection method for this purpose and sponsored a modest research program with this objective at Brown University.

At Brown, integral equations were formulated and a solution obtained for a very long room with unilateral fenestration. This work makes it possible to calculate the *actual* distribution of light (including interflections) on wall, floor and ceiling when the *direct* component of the distribution is known or obtainable from photometric data on a particular type of fenestration.

Using tables developed for very long rooms with perfectly diffused fenestration, results such as

Authors: University of Connecticut, Storrs, Conn. (formerly Brown University); Brown University, Providence, R. I.; Pittsburgh Corning Corp., respectively.

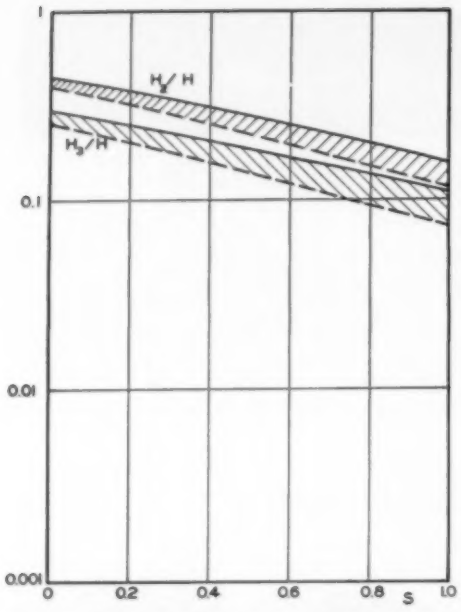


Figure 1. Comparion of distribution of light in a shallow room, ——— with interflections, — — — without interflections.

shown in Fig. 1 may be obtained easily by multiplying fenestration brightness by one factor from the proper table.

The importance of interflections is shown in Fig. 2. The effect is maximum at the back of the room, where interfleections may increase the light from the ceiling or floor from 1¼ to 4½ times depending on room and fenestration proportions.

To provide a physical check on the mathematical analysis, a room model duplicating the conditions assumed in setting up the equations was built at the Pittsburgh Corning Daylighting Research Center. Using photocells installed in the model and connected to a Brown Electronic Recorder, a large number of brightness distribution patterns were obtained.

Table I shows how the results of these measurements compare with the distribution pattern calculated by the interflection method.

Conclusions.—The principal conclusions of this paper are:

(1) The interflection method can be applied in a significant fashion to the design and performance of various diffusing fenestrations.

(2) Performance data obtained by direct measurement at the Pittsburgh Corning Daylighting Research Center in models with diffusing fenestrations are in agreement with those calculated using the interflection method.

Thus, it appears possible to develop an inter-

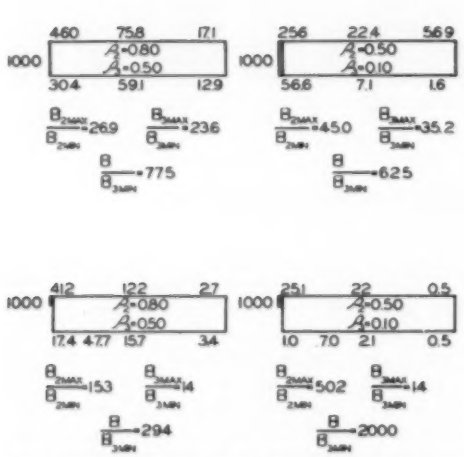
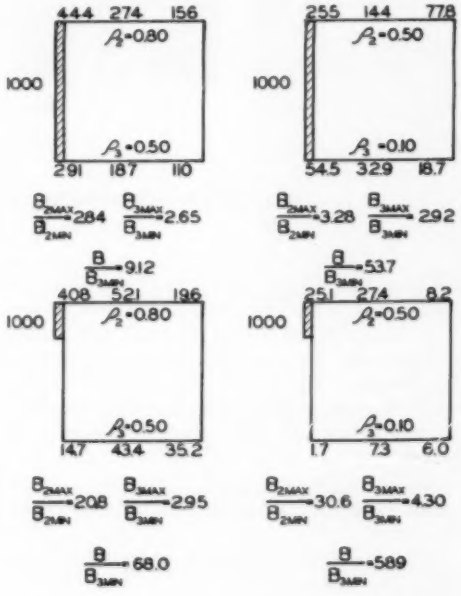


Figure 2. The brightness distribution (blondels) in very long rooms with various reflectances, and narrow or complete perfectly diffusing windows. The brightness of the window is 1000 blondels. One blondel equals 9.290×10^{-2} footlamberts. (Above) deep room, $k_r = 0.10$. (Right) shallow room, $k_r = 0.50$.



flection method which will permit the illuminating engineer to design for daylighting in a scientific way. For the interflection method to become a ready tool for the illuminating engineer, it will be necessary to prepare appropriate application data, in tabular or graphic form for the important fenestration types, room proportions, and surface reflectances.

In this work the cooperation of R. B. Lindsay, J. R. O'Connor, James Lee, Mary Sullivan of Brown University's Physics Department and of A. H. Baker, D. D'Eustachio and W. H. Billhartz of the PC Daylighting Research Center was most helpful.

TABLE I.—Per Cent of Light from Each Quarter of Perfectly Diffusing Fenestration Wall Incident on Ceiling or Floor at Rear of Room.*
(Reflectance of Ceiling = 0.80)
(Reflectance of Floor = 0.30)

	Shallow Room (Depth same as height) ($k_r = 0.50$)		Deep Room (Depth 5 times height) ($k_r = 0.1$)	
	On Ceiling	On Floor	On Ceiling	On Floor
Upper Quarter.....	12%	32%	14%	37%
Second Quarter.....	24	27	16	20
Third Quarter.....	30	24	28	24
Lower Quarter.....	34	17	42	29

*Backwall perfectly absorbing.

(Abstract of I.E.S. 1951 Conference Paper No. 21)

Coefficients of Utilization For Luminaires With Concentrating Distributions

J. R. Jones

John J. Neidhart

THE coefficients of utilization used in the familiar Lumen Method of calculating interior illumination are currently being calculated by an empirical method that does not fully recognize differences in distribution of light flux from the luminaire. They are based upon the percentage of downward flux in the arbitrary and rather wide zone from 0°-40°; and the method fails to provide for any increase in utilization when more than 65 per cent of the downward flux is in this zone even though many modern luminaires have flux ratios of over 90 per cent.

Although the Interflection Method appears to be more accurate and is applicable to all distributions, it was not carried to a conclusion that permits using it directly to calculate coefficients of utilization. Another limitation of this method is its assumption that the working plane is ¼ the distance from the floor to the ceiling. This may cause considerable error in high bay calculations, but the error can be largely eliminated by calculating separately the flux that strikes the work plane directly as was done in this paper.

Authors: Westinghouse Electric Corp., Lamp Division, Bloomfield, N. J.

To overcome the weaknesses of existing methods, the authors are proposing a method of calculating coefficients of utilization for use in the Lumen Method that considers the ultimate dispo-

1000-WATT CONCENTRATING LUMINAIRE

ZONE	ZONAL LUMENS	ZONAL MULTIPLIER	PRODUCT
0°-10°	3005	1.00	3005
10°-20°	5580	.72	4020
20°-30°	3125	.57	1782
30°-40°	2310	.34	785
40°-50°	1180	.16	189
50°-60°	129	.03	4
60°-70°	40	–	–
70°-80°	–	–	–
80°-90°	–	–	–
TOTAL	15369		9785

DIRECT RATIO = $\frac{9785}{15369}$ = .635

C.U. = $\frac{15369}{21000^*}$ (.635 + .01) = .47

* LAMP LUMENS - 21000

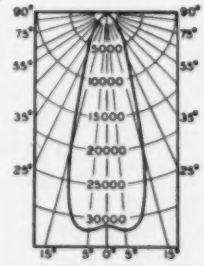


Figure 1. Calculation of the coefficient of utilization for a "J" room. The downward reflected component is .01 for 30% ceiling and 10% wall reflectances.

sition of flux from every 10° zone. The flux in each 10° zone (0°-10°, 10°-20°, etc.) that strikes the work plane directly is determined, and to that is added the flux that reaches the work plane by interreflection. The ratio of the total flux reaching the work plane to the lamp lumens is the coefficient of utilization. By means of tabulated zonal multipliers, for each zone and room shape (room index) and a series of curves (calculated by the Interflection Method) for each room index and ceiling and wall reflectance, the necessary calculations to obtain the coefficients are reduced to a rather simple and straightforward process. A sample calculation (less curves for the reflected component) is shown by Fig. 1.

Although this method of calculating coefficients was developed primarily for direct luminaires, it soon became apparent that it was also applicable to distributions in which part or all of the light was directed upward. An additional table of zonal multipliers makes it possible to calculate the percentage flux striking the ceiling directly, and a series of curves enables one to convert this flux and that striking the upper walls to a percentage reaching the work plane. This percentage when added to the percentage of direct and reflected flux from the 0-90° zone reaching the work plane is the coefficient of utilization.

In adopting this proposed system, the lighting engineer using the Lumen Method *does not* have to change his method of making lighting calculations. The time required to calculate a complete set of coefficients by this proposed Zonal Method is only slightly longer than that required by the currently used method. Certainly the greater accuracy obtained more than justifies the small amount of additional work which must be performed only once for each luminaire.

(Abstract of I.E.S. 1951 Conference Paper No. 13)

Stroboscopic and Flicker Effects from Fluorescent Lamps

Arthur A. Eastman

John H. Campbell

THE investigation in this paper was prompted by what the authors believe to be a general misconception as to the actual amount of cyclic flicker from fluorescent lamps, and its effects. The amount of flicker from fluorescent lamps varies with the type of operating circuit and with the decay rate of the phosphor used. Filament lamps also flicker and it can be shown that the flicker and stroboscopic effects from some filament lamps are about the same as with some fluorescent lamps.

Oscilloscope traces of the light from pairs of fluorescent lamps were obtained with two photocells coupled to the oscilloscope through an elec-

Authors: General Electric Co., Nela Park, Cleveland, Ohio.

TABLE I.

Circuit	40-w Daylight Per Cent Flicker	40-w Daylight Flicker Index	40-w Standard Cool White Per Cent Flicker	40-w Standard Cool White Flicker Index	40-w Standard Warm White Per Cent Flicker	40-w Standard Warm White Flicker Index	Phase Angle
Single lamp series reactor preheat start	58.4	0.152	44.7	0.117	37.5	0.077	68°
Multiple two-lamp split-phase preheat start	24.0	0.080	15.7	0.046	9.9	0.027	35°
Multiple two-lamp split-phase instant-start	39.1	0.122	31.2	0.097	16.9	0.048	
Series two-lamp sequence-start	65.5	0.203	53.3	0.140	35.5	0.090	
Series two-lamp sequence-start	59.8	0.167	44.0	0.125	26.9	0.076	

	Per Cent Flicker	Flicker Index
40-watt filament	12.2	0.043
60-watt filament	6.8	0.027
100-watt filament	5.1	0.009

tronic switch. With one cell receiving the light from both lamps, and the other cell in the dark, a trace was obtained of the wave forms along with a base line. These traces were analyzed with the help of two formulas: (1) per cent flicker and (2) flicker index.

Per cent flicker, formula (1) is expressed by the equation:

$$\text{Per cent Flicker} = \frac{\text{Max} - \text{min}}{\text{Max} + \text{min}}$$

Per cent flicker is commonly used, but it will not differentiate between different wave forms since it depends only on maximum and minimum value of light. The flicker index formula is proposed as being more meaningful in that it gives ratings which are in accordance with the flicker response of the human eye.

Fig. 1 shows the derivation of the flicker index formula, where A_a is the area under the curve over the average line, and A_t is the total area under the curve for one complete cycle.

Table I gives both the per cent flicker and flicker index ratings for three colors of fluorescent lamps operated with five different circuits. Ratings are also given for three filament lamps. Comparisons can be made readily, and it is seen that differences between circuits may be less than differences between colors of lamps on the same circuit. It should also be noted that the indexes for some fluorescent lamps and circuit are lower than the index for the 40-watt filament lamp. The observed stroboscopic effect is in the same order as the flicker indexes for the various lamps and circuits.

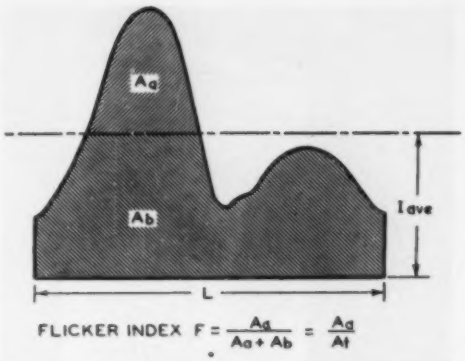


Figure 1. Typical curve of end flicker for a standard cool white fluorescent lamp showing method of calculating flicker index, *F*.

The proposed flicker index should be of value in the study of phosphors and in the study of circuit and ballast designs. However, the flicker from fluorescent lamps appears to be of only academic interest since properly shielded fixtures will eliminate direct observation of the lamps. The stroboscopic effect is of very little importance in the majority of installations, but where it is important, the flicker index should be helpful in the choice of lamps and circuits.

(Abstract of I.E.S. 1951 Conference Paper No. 3)

A New Laboratory for Lighting Design Data

DEVELOPMENTS in light sources, new lighting techniques and trends in lighting practice have brought with them a need for additional, more comprehensive tested design data applicable to many conditions not covered by the long familiar Harrison-Anderson room-index method and utilization data. Results in localized areas and on vertical and oblique planes are of growing concern, as are varied brightness patterns and their effect on comfort and appearance.

To facilitate production of required new information, a unique new laboratory has been created

Authors: Engineering Department, Lamp Division, General Electric Co., Nela Park, Cleveland, Ohio.

Wentworth M. Potter

Anson H. Russell

Figure 1. (Left) The smallest square room of the new laboratory (12½ feet x 12½ feet) with maximum ceiling height of 16 feet. Two wall panels removed to show interior.

Figure 2. (Above) Operation center (A) control panel for scanning equipment, recorder and integrator; (B) automatic recording instrument; (C) integrator; (D) winch control button. Voltmeter and controls for test and calibrating lamps and for integrator circuits, left.

at Nela Park. Flexibility is a keynote. The room structure is assembled with quickly-demountable steel channel, making possible construction of rooms of various sizes and shapes. Room proportions are readily changed by a movable ceiling, which is suspended by wire ropes connected to a motor driven winch. Ceiling, wall, and floor panels can be changed quickly to any desired pattern of color or reflectance, and lighting elements and lamps of any type can be installed and shifted about.

Rooms up to 30 feet square may be set up at full scale, making possible subjective appraisals of comfort and permitting investigation of inaccuracies that may be inherent in smaller scale model rooms with lighting units of normal size. The smallest room is shown in Fig. 1 at maximum height.

Explorations of illumination in any desired plane are made with a high-precision, mechanically-propelled photometric head on a movable track. Motion of the carriage and track may be controlled either manually by push button at the operation center, Fig. 4, or in an automatic cycle of operation. Thus, the light-sensitive cell may be moved to any position, a peak of illumination searched out, or a complete exploration made, all without the operator entering the room.

Curves of illumination values are automatically plotted by a recording instrument whose strip chart moves in synchronism with the photometric head. A specimen recording for ten equally spaced traverses across a quadrant of the room is shown in Fig. 3. Such records are available for studies of distribution and utilization in particular areas. Simultaneously, an automatic device integrates these curves, providing counts which are instantly convertible to average footcandles or lumens delivered.

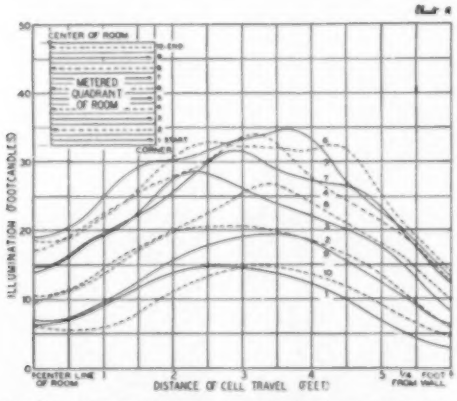


Figure 3. Typical illumination distributions recorded in a quadrant of a 12½′ x 12½′ room of ratio 0.8 with surface reflectances: ceiling, 0.80; wall, 0.40; floor, 0.17. Sources, 150-watt PAR-38 floods, shielded to 45 degrees, operated at about 100 volts. Units centered over quadrants. Chart indicates horizontal illumination along centers of 7½″ strips 30″ above floor.

(Abstract of I.E.S. 1951 Conference Paper No. 24)

An Analysis Of Fluorescent Luminaire Brightness Limitations

John J. Neidhart

THE importance of controlling luminaire brightness has led many of our technical committees to recommend *maximum* brightness and/or shielding angles. Concurrently, others have devised techniques in which *average* luminaire brightnesses are used to predetermine the amount of comfort or discomfort that may be expected from an installation. The need for some correlation between maximum and average brightnesses is obvious, and the possibility of using average brightness as a performance criterion is worthy of consideration.

The maximum brightness data upon which we place so much emphasis today is actually unworthy of the importance attached to it. The values shown on photometric data sheets are frequently not true maximums found by thorough exploration. Even when the measurements are made conscientiously by skilled technicians, they are very tricky and may be altered considerably by small mechanical variations in the equipment or shielding media. Furthermore, the I.E.S testing guide permits the use of different instruments that will produce results as different as those shown in Table I.

Author: Westinghouse Electric Corp., Cleveland, Ohio.

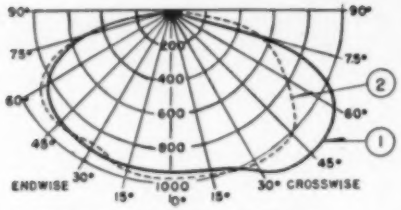
The average brightness of a luminaire is merely the candlepower divided by the projected area of the luminous portions of the luminaire at a given angle and viewing direction. Since candlepower measurements are more reliable and projected areas for crosswise and endwise viewing can be obtained graphically or mathematically with reasonable ease and accuracy, average brightness data can be regarded with greater faith than can maximum brightness data.

By means of curves and data similar to Fig. 1, average and maximum brightnesses of several representative fluorescent luminaires are compared. Several types of direct, semi-direct, direct-indirect, semi-indirect, and indirect luminaires are included to show the effects of both distribution and method or degree of shielding. The average brightnesses are presented in the form of smooth curves, and maximum brightnesses and ratios of maximum to average brightnesses are tabulated for all angles for which maximum brightness data were available.

The data seem to indicate that average brightness is a satisfactory means of indicating luminaire performance as it may affect comfort. In Fig. 1, for example, the improvement resulting from the addition of a longitudinal shield is clear-

TABLE I.—Comparison of Maximum Brightnesses for a Direct-Indirect Luminaire with 30° x 30° Louver Bottom Using the Different Techniques Approved in the I.E.S. Test Procedure or in Common Laboratory Use.

Angle	Viewing Direction	Photo-Electric Type Meter						Visual Type Meter (Luckiesh-Taylor)	
		1" x 1" Aperture		½" x 2" Aperture		¼" x 4" Aperture			
		Footlamberts Brightness	Relative Brightness	Footlamberts Brightness	Relative Brightness	Footlamberts Brightness	Relative Brightness	Footlamberts Brightness	Relative Brightness
0°	——	2033	101	2064	102	1940	95	2141	105
30°	Crosswise	2168	100	2262	104	2207	102	2223	103
	Endwise	1986	100	1986	100	1627	82	1923	97
45°	Crosswise	1579	100	2074	131	2010	127	2178	138
	Endwise	1752	100	1335	76	1302	74	1918	109
60°	Crosswise	656	100	885	135	1038	158	1217	186
	Endwise	775	100	723	93	651	84	1436	185
75°	Crosswise	211	100	257	122	281	133	289	137
	Endwise	268	100	268	100	234	87	303	113
90°	Crosswise	710	100	360	51	1126	158	1056	149
	Endwise	—	—	—	—	—	—	—	—



No. 1—2-lamp 40-watt industrial luminaire.
No. 2—Same as No. 1 except with longitudinal shield.

Angle	Viewing Direction	Luminaire #1 Maximum Brightness	Luminaire #1 Max. to Avg Brightness Ratio	Luminaire #2 Maximum Brightness	Luminaire #2 Max. to Avg. Brightness Ratio
0°	——	2385	2.5	2245	2.3
45°	Crosswise	2530	2.2	2195	2.2
	Endwise	1950	2.2	2195	2.3
60°	Crosswise	2485	2.2	1660	2.2
	Endwise	1655	2.0	1660	1.9
70°	Crosswise	1950	2.2	875	1.5
	Endwise	1460	2.3	1410	1.8

ly shown. Whether or not it can be used alone is subject to conjecture. If at least some reference to maximum brightness is believed necessary, it can be expressed best in the form of the ratio of maximum to average brightness. Such a step would place the emphasis upon the more reliable average brightness where it belongs and would permit better correlation between photometric data and comfort evaluation systems. At the same time, the ratio of maximum to average brightness would disclose any possible small area "hot spots" of brightness that might be present in some types of incandescent luminaires and would thereby make the system suitable for both fluorescent and incandescent luminaires. It is very doubtful that there would be any significant "hot spots" with fluorescent luminaires since the maximum brightness of the representative luminaires studied was generally only 1.5 to 5 times the average brightness thus indicating that the ratio is probably unnecessary for fluorescent luminaires.

(Abstract of I.E.S. 1951 Conference Paper No. 23)

Left to right:

Caroline E. Horn
William F. Little
Ernest H. Salter

Relation of Distance to Candlepower Distribution From Fluorescent Luminaires

VARIOUS workers have pointed out the limitations of measurement and of computation of illumination as affected by source size and the distance from source to point of observation. There has been some tendency to follow rules developed for incandescent sources in applications involving fluorescent sources.

It is the purpose of this paper to examine into the effects of photometric distance and measurements procedures on the resulting determinations of light output, candlepower distribution and efficiency of fluorescent lighting units. The results serve to

(1) Justify the three-plane method of photometry as commonly applied to fluorescent fixtures.

(2) Show that reasonably accurate measurements can be obtained only when the ratio of maximum source dimension to photometric distance is of the order of 1:5.

(3) Show that work at shorter photometric distances may yield reasonably close light-output and efficiency values, but show a badly distorted picture of the candlepower distribution.

(Abstract of I.E.S. 1951 Conference Paper No. 19)

Authors: Electrical Testing Laboratories, Inc., New York, N. Y.

Verification Of the Interflection Tables

R. D. Churchill

Russell C. Putnam

ILLUMINATING engineers have come, over the years, to the realization that satisfactory and comfortable lighting requires control of brightness distribution throughout the visual field. Lighting design should, therefore, include computation of the brightness distribution if it is to predetermine completely the performance of a lighting installation.

The lumen method of lighting calculation has allowed computation of the working plane illumination while the interflection method now permits computation of surface brightnesses. No experimental verification of the theoretical interflection tables has been published previously.

This paper summarizes an experimental study of the accuracy of the theoretical interflection tables for a series of model room sizes lighted by a luminous ceiling. The conditions were limited to those on which these tables are premised; all surfaces diffuse, ceiling of uniform brightness, and each surface of uniform reflectance.

The investigation was conducted in a model room with maximum internal dimensions of six feet in all directions. The room ratio value was varied from 0.167 to 1.000 by changing the room height while the floor area remained constant. Fig. 1 shows an exterior view of the experimental room. Illumination and brightness readings were recorded from outside the room through removable sections in the floor and one wall. The room surfaces were painted with integrating sphere paint in order to approach perfectly diffusing surfaces as closely as possible.

The luminous ceiling was formed of tracing paper and illuminated from a cavity utilizing silvered-bowl incandescent lamps. Through lamp arrangement in the cavity, voltage control to various groups of lamps, and the use of polished aluminum sheet on the cavity sides, the ceiling brightness uniformity was such that the maximum variation was only 3 per cent from the average value.

Since the ratios under consideration involve both brightness and illumination, it was desirable to measure both variables with the same instrument in order to minimize inherent instrument errors. For this reason the Luckiesh-Taylor Brightness Meter was used for all measurements. Illumination values at the working plane height were measured by use of a magnesium oxide disk.

The investigation showed a very close agreement between experimental and theoretical values of interflection ratios for the specific conditions of the test room. The maximum difference found between experimental and theoretical values was 4 per cent. This experimental verification gives assurance of the validity of this method of lighting design. The accuracy of the practical application of this method depends upon the actual room conditions in much the same manner as does the accuracy of the lumen method of lighting calculation.

(Abstract of I.E.S. 1951 Conference Paper No. 26)

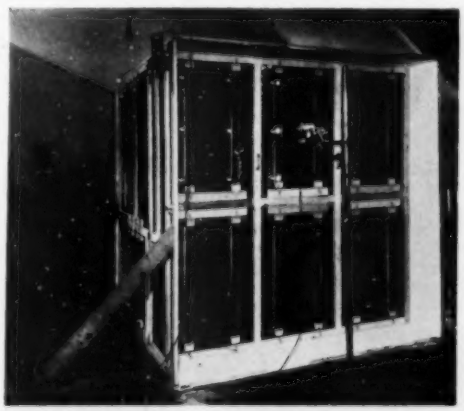


Figure 1. Exterior view of the experimental room with the floor in position for a room ratio of 0.833. The Brightness Meter is placed to read the ceiling brightness through one of the apertures.

Authors: Russell C. Putnam, Case Institute of Technology, Cleveland, Ohio; R. D. Churchill, Lamp Division, General Electric Co., Nela Park, Cleveland, Ohio.

Harry E. Shultz

Delmar D. Kershaw

Television Interference From Filament Lamps

SINCE 1940 it has been known that the S-1 type of filament in a vacuum lamp could cause interference in the 60 to 70 megacycle frequency range. Although these lamps have not been manufactured since 1925, more cases of interference have occurred than was originally anticipated. The reason for this is that these lamps have been used in such places as attics, fruit cellars and closets where their intermittent use extends their life.

Fig. 1 shows a photograph of a typical straight wire vacuum lamp. The main points of identification are the filament shape, the clear glass bulb and the tip.

The oscillations are produced by a "Barkhausen" type of oscillation which takes place between the two end sections of the filament. Each section acts alternately as an anode drawing electrons from the opposite end and a cathode giving up electrons to the opposite section. When acting as an anode many of the electrons drawn toward it miss and take an eliptical path about the filament inducing an RF field and producing the interference.

Fig. 2 shows the relative magnitude of the interference frequencies and the relation of the frequency to the voltage applied to the lamp. Since these lamps are operated on 60-cycle, the frequency is modulated by each half of the 60-cycle wave. Lamps vary in that some will produce oscillations on only one-half of the 60-cycle wave and the frequency range will vary from lamp to lamp. In all

Authors: General Electric Co., Nela Park, Cleveland, Ohio.

Figure 1. The straight wire vacuum type of lamp that causes television interference.

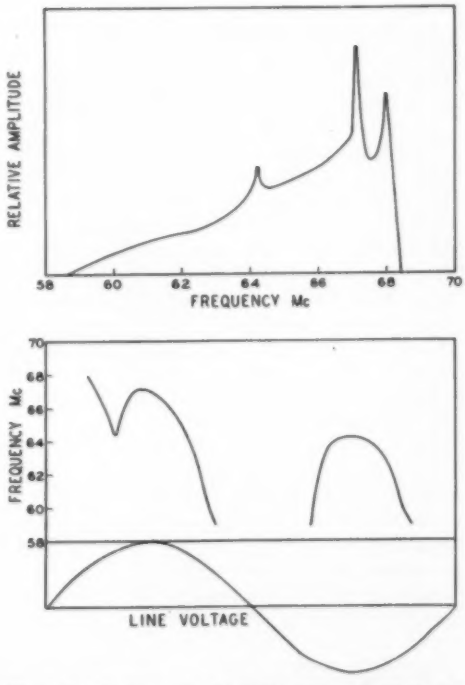


Figure 2. The top curve shows the relative amplitude of the lamp oscillation versus the frequency generated for a typical lamp. The lower curve shows the relation of the frequency generated to the instantaneous 60-cycle line voltage for a typical lamp.

Figure 3. Pictures A, B, and C are typical television interference patterns caused by lamps of the type shown in Figure 1. Picture D is the result of operating the lamp very near the television receiver.

lamps the frequency range increases as the line voltage is increased.

In television the interference appears in one or two horizontal bars depending upon whether the lamp is oscillating on one or both halves of the 60-cycle wave. The position of the bars may be stationary or moving up or down depending upon the power line phase relation to the vertical scanning frequency. The channels most affected are 2, 3, and 4.

Fig. 3 illustrates various interference patterns caused by lamps of this type. There is a wide variety of equipment such as motors, shavers, ignition systems and diathermy, that cause interference on television. However, diathermy is the only one that appears similar.

Lamps of this type have been known to cause interference for a radius of three blocks, however, the distance will vary with different lamps and the type of installation. The simplest remedy for this type of interference is to find and replace the guilty lamp. Various means could be used to shield the lamp, but they would be more costly than replacing the old lamp with a modern, more efficient lamp.

(Abstract of I.E.S. 1951 Conference Paper No. 33)

Maintenance of Industrial Lighting

DEFENSE mobilization imposes on industry an imperative responsibility for the most effective use of production facilities and manpower. Good lighting becomes more vital than ever, and therefore unnecessary waste of light resulting from a lack of maintenance should not be tolerated. To add to the available but limited data on loss due to dirt the authors have undertaken tests in some 13 factory areas in two industrial cities, representing different degrees of cleanliness or dirt prevalence.

Gain on Initial Cleaning.—The heavy penalty

C. E. Egeler

R. F. VandenBoom

Authors: General Electric Co., Nela Park, Cleveland, Ohio.

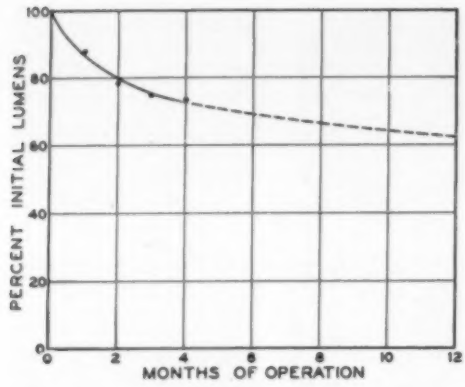


Figure 1. Depreciation rate of light output due to luminaire dirt in engine assembly area.

suffered in factory areas due to lack of maintenance is shown by the "before" and "after" data on Table I. An average light loss of 53 per cent overall was found in the six plant areas where maintenance had been neglected. Dirt on the lamps alone accounted for an average loss of 19 per cent, while that on the reflectors was responsible for a 28 per cent reduction in delivered light.

Rate of Depreciation.—For all luminaires in the plant areas, the average drop in output from the clean-reflector, new-lamp condition at the end of only three months was 31 per cent. After deducting lamp depreciation, the loss in three months due to dirt collection varied from 3 per cent in the woodworking shop to as high as 37 per cent (average) in the foundry.

Economic Value of Planned Maintenance.—If the amount of light loss during a given period is known, the economic value of cleaning can be determined, using energy and labor costs applying for the plant in question. Taking the engine assembly area as a typical example, the average loss due to dirt collection was 25 per cent at the end of 3 months, with about 31 per cent indicated (Fig. 1) at the end of 6 months. Without cleaning, the loss will approach 45 per cent. Even if the luminaires are cleaned only once in six months there would be a gain in illumination of about 42 per cent above the asymptotic value.

The operating cost of a lighting system always involves energy, lamp and lamp replacement (labor) costs. In a typical medium-sized plant with the costs shown in Fig. 2, two cleanings per year will provide a 42 per cent increase in illumination or $3.40 worth of light. Even neglecting the substantial reduction in required investment for a given average illumination, any cleaning cost up to $1.70 per fixture pays a real dividend Based on a cleaning cost of 35c each per two 40-watt fluorescent lamp industrial luminaire, the bars at the left of the chart, Fig. 2, show that an additional operating expense of only 9 per cent or 70c, yields a $3.40 return in added illumination.

TABLE I.—Rate of Depreciation of Illumination in Industrial Areas.

Area	Luminaire Type and Finish	No. of Luminaires	Average Burning Hours Per Month	Light Output After Subsequent Service Without Cleaning							
				As Found	After Relamping Only	After Cleaning & Relamping	1 mo.	2 mo.	3 mo.	4 mo.	And After Deducting Lamp Depreciation: 1 mo.	2 mo.	3 mo.	4 mo.
Low-Bay Areas														
Woodworking	2-40W Synthetic	3	325	53%	69%	100%	89%	84%	82%	77%	99%	98%	97%	94%
Laboratory	2-40W Synthetic	2[c]	250	—	—	100	88	87	83	76	—	—	—	98
"	2-40W Porcelain	2	250	53	79	100	92	91	85	80	—	—	—	—
Core Room	2-85W Porcelain	2	200	35	57	100	79	69	66	54	86	77	76	65
Engine Assembly A	2-40W Porcelain	2	375	69	88	100	77	64	58	57	86	75	71	71
Engine Assembly B	2-85W Porcelain	2	200	41	77	100	83	73	68	65	90	82	79	77
Office	2-40W Synthetic	1[c]	180	—	—	100	96	89	86	73	—	—	98	86
"	1-40W Aluminum	2[s]	180	62	97	100	96	93	89	81	—	—	—	95
High-Bay Areas														
Foundry	2-40W Synthetic	2[c]	250	—	—	100	60	54	52	44	66	62	61	59
"	2-40W Porcelain	2	250	—	—	100	70	62	57	54	77	72	67	66
"	2-85W Porcelain	2	250	28	68	100	63	58	52	48	70	67	61	58
Warehouse	2-40W Synthetic	1[c]	600	—	—	100	89	88	86	76	—	—	—	98
Welding	2-40W Synthetic	2[c]	250	—	—	100	79	70	65	61	86	79	76	74
Machine Shop (Heavy)	2-40W Synthetic	2[c]	175	—	—	100	88	82	77	71	94	91	88	83

[c] Control luminaires of the RLM type.
[s] Single-lamp aluminum troffers.
All other industrial luminaires of the RLM type.

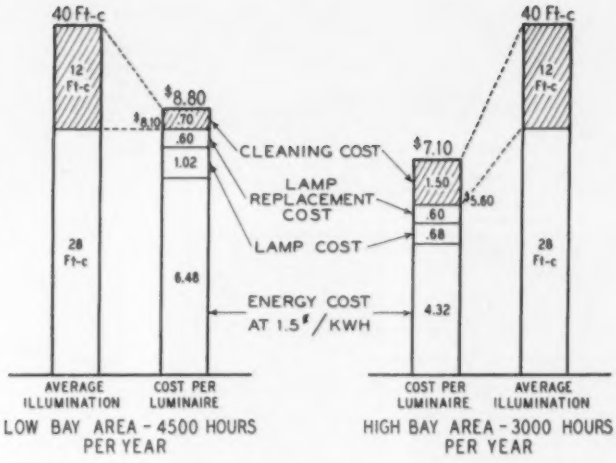


Figure 2. Cross-hatched portions show added annual operating costs and illumination increases for two cleanings per year—two-lamp 40-watt fluorescent industrial luminaires.

In high bay areas cleaning costs are usually greater and are largely dependent upon the accessibility of the lighting equipment. The data at the right of Fig. 2 show that in the welding shop a maintenance schedule of two cleanings per year should provide 41 per cent increase in illumination for an additional operating cost of 27 per cent.

(Abstract of I.E.S. 1951 Conference Paper No. 7)

Fundamentals Of Lighting Cost Analysis

A. C. Barr

C. L. Amick

COST is nearly always a factor in the selection of a lighting system. When the lighting performance of different systems is similar, the comparative cost may become the deciding factor.

Many papers and articles have included relative costs of various illumination systems. A uniform computation procedure is proposed, forming the framework into which specific charges applying to a particular installation can be fitted. For example, quick and fair comparisons of cost data from different individuals are possible only if (1) costs are equated to an equal footcandle level in service, (2) equal amortization rates are used, (3) equal operating conditions are employed, (4) cleaning schedules are appropriate for each type of system and (5) uniform labor rates are used for estimating the cost of installation, cleaning and relamping.

The accompanying table shows the uniform method proposed. In the paper, typical values are given for three medium-bay industrial lighting systems. Section A covers the basic data necessary to equate illumination performance, and also tabu-

Authors: Lamp Division, General Electric Co., Nela Park, Cleveland, Ohio.

TABLE I.—Cost Analysis. Industrial Lighting Systems — 25-Foot Mounting Height.

	Luminaire Description (Porcelain enamelled steel reflectors)	I — Fluorescent 4 85-watt T17 Std. Cool White 4-lamp ballast 265-volt primary		II — Mercury 1 400-watt E-H1 2-lamp ballast 230-volt primary		III — Filament 1 1000-watt PS-52 120 volts	
	Basic Data						
	1. Rated initial lamp lumens per luminaire	17,600		20,000		21,500	
	2. Lamp life	7,500		(e) 3000	4000	1000	
	3. Average watts per lamp	82		400		1000	
A	4. Watts per luminaire (includes ballast watts)	364		430 (f)		1000	
	5. Coefficient of utilization (a)	.62		.59		.39	
	6. Maintenance factor (b)	.65		.65 (g)		.65	
	7. Effective maintained lumens per luminaire (1 × 5 × 6)	7090		7675		8250	
	8. Relative number of luminaires needed for equal maintained footcandles	7		.924		.860	
	Initial Costs						
	9. Net luminaire cost (estimated)	$63.00		$25.50		$ 8.60	
	10. Installation (c)	$18.00		$17.00		$11.00	
	11. Net initial lamp cost including tax (estimated)	$ 8.30		$13.60		$ 2.50	
B	12. Total initial cost per luminaire	$89.30		$56.10		$22.10 (h)	
	13. Annual owning cost per luminaire 15% of (9 + 10)	$12.15		$ 6.40		$ 2.95	
	14. Relative initial cost for equal maintained footcandles (12 × 8) / (12 × 8) for column I	100%		58%		21% (h)	
	Annual Operating Costs	**2500**	**4000**	**2500**	**4000**	**2500**	**4000**
	15. Burning hours per year						
	16. Annual energy cost (4 × 15 × rate in c per KWH) / 100,000	1c per KWH	$ 9.10	$14.60	$10.75	$17.20	$25.00	$40.00
		2c per KWH	$18.20	$29.20	$21.50	$34.40	$50.00	$80.00
		3c per KWH	$27.30	$43.80	$32.25	$51.60	$75.00	$120.00
	17. Number of lamps replaced per year (15 × no. lamps per unit) ÷ Item 2		1.33	2.14	0.83	1.00	2.50	4.00
C	18. Lamp cost (17 × net price per lamp including tax)		$ 2.75	$ 4.45	$11.30	$13.60	$ 6.25	$10.00
	19. Labor cost of lamp replacements		$ 1.25 (d)	$ 2.05 (d)	$ .65	$ .75	$ 1.85	$ 3.00
	20. Cost of cleaning twice per year		$ 1.80	$ 1.80	$ 1.00	$ 1.00	$ 1.00	$ 1.00
	21. Total annual operating cost per luminaire (16 + 18 + 19 + 20)	1c per KWH	$14.90	$22.90	$23.70	$32.55	$34.10	$54.00
		2c per KWH	$24.00	$37.50	$34.45	$49.75	$59.10	$94.00
		3c per KWH	$33.10	$52.10	$45.20	$66.95	$84.10	$134.00
	22. Relative annual operating cost for equal maintained footcandles (21 × 8) / (21 × 8) for column I	1c per KWH	100%	100%	147%	131%	197%	202%
		2c per KWH	100%	100%	133%	123%	212%	215%
		3c per KWH	100%	100%	126%	119%	218%	221%
	Total Annual Costs							
	23. Relative total annual cost for equal maintained footcandles (13 + 21) × 8 / (13 + 21) × 8 for column I	1c per KWH	100%	100%	103%	103%	(h) 118%	140%
D		2c per KWH	100%	100%	104%	104%	148%	168%
		3c per KWH	100%	100%	105%	105%	165%	183%

(a) For room index D — 50% ceiling, 30% walls.

(b) Includes mean lamp depreciation and mean dirt depreciation during life, with two cleanings per year.

(c) Does not include wiring costs.

(d) Includes one starter replacement (at 50c) for every two lamps replaced.

(e) Rated life at 5 and 10 hours per start, respectively.

(f) Ballast watts and cost given are half of 2-lamp values.

(g) Average for lamp lives given in item 2.

(h) Wiring requirements of filament lighting systems are much greater than for fluorescent or mercury systems. This should reflect in substantially higher initial (and, therefore, total annual) cost than shown here.

lates the lamp life and over-all wattage for convenience in calculating operating costs. Section B gives initial costs, which should wherever possible include both installation and wiring charges in addition to charges for the luminaires and the initial set of lamps. For luminaires, a uniform 15 per cent write-off rate is suggested, which allows 10 per cent for amortization and 5 per cent for interest, taxes and insurance. The wiring system would ordinarily be amortized at a lower rate. Item 14 gives the relative initial cost for the different systems being compared.

Section C covers the annual operating costs of electrical energy and lamps, and the labor charges for cleaning and lamp replacement. Since operating cost may be a bigger factor than initial or total annual cost in some cases, Item 22 is included to permit quick comparisons of different systems under study. Section D gives the relative total annual costs, which will be of greatest interest to most lighting customers.

The paper explains the simple procedure for estimating actual dollars cost and mentions the use of cost analyses to determine optimum cleaning intervals, the economy of group or spot replacement methods, etc. Of course, cost comparisons exclude considerations of relative lighting quality, which should be covered by suitable accompanying explanations.

(Abstract of I.E.S. 1951 Conference Paper No. 2)

From the Session on

Sources

Color Correction and Other Important Improvements In Mercury Lamps

H. D. Fraser

W. S. Till

NEW DESIGN features have greatly improved mercury vapor lamps. The most important recent improvement is the development of a color corrected mercury lamp. This lamp has its outer bulb coated with a newly developed high temperature phosphor which adds red to the mercury spectrum and so provides a pleasing color of white light suitable for most industrial purposes and floodlighting applications. Other improvements include a new method of introducing lead wires into quartz arc tubes, larger arc tubes, larger outer bulbs made of lime glass, and a new high temperature basing cement. These improvements have resulted in longer life, better maintenance and greater dependability for mercury lamps.

Authors: Westinghouse Electric Corp., Lamp Division, Bloomfield, N. J.

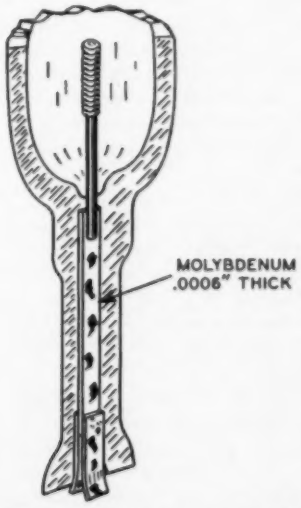


Figure 2. Thin metal ribbon, vacuum sealed into quartz, eliminates strain and provides dependable means of introducing lead wires into quartz arc tubes.

The new method of sealing lead wires into quartz makes use of a new type of ribbon seal consisting of thin molybdenum metal pressed between two walls of quartz or other similar material. (See Fig. 1.) The ribbon is so thin that the forces exerted by expansion and contraction are negligible and a vacuum tight seal is effected. Previously most mercury lamps used a graded glass seal which often developed cracks at unpredictable stages of lamp life even though carefully controlled methods were used in their manufacture.

Other improvements contributing to a better mercury lamp are the use of a larger arc tube diameter and a larger "isothermal" lime glass outer bulb. The arc tube diameter has been designed to provide best overall balance between high efficiency, long life and good maintenance. The larger outer envelope, illustrated in Fig. 2, is designed to be approximately isothermal, and has a lower temperature during operation of the lamp.

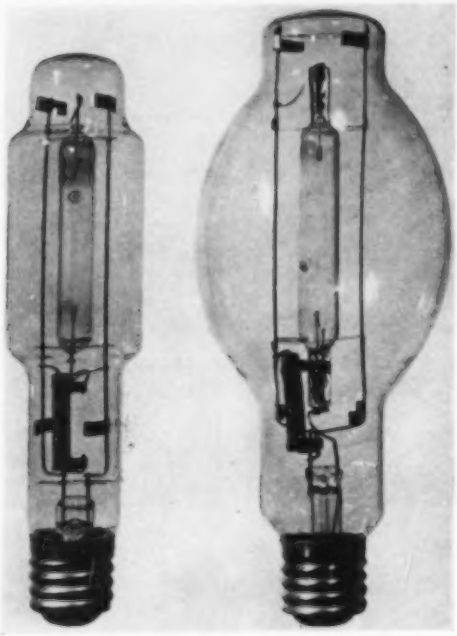


Figure 9. Substitution of J-H1 for A-H1 raises illumination level and provides color correction.

Figure 3. New larger "isothermal" bulb and larger arc tube, with ribbon seal, have greatly improved performance of quartz mercury lamps. The old and new 400-watt type E-H1 lamps are illustrated.

Lime glass is used because it was found to be especially satisfactory with the new design, with less evolution of water vapor during operation than other glasses.

A new silicone basing cement has been developed which retains its adhesive properties at high temperatures over long periods of time. It can be used in place of ordinary cement in regular type bases and when used in this manner makes an excellent material for basing high temperature lamps. By this method it is possible to eliminate the often troublesome mechanical base.

Mercury lamps have been widely accepted for industrial lighting and other applications because of their long life, high efficiency and high output but in many cases their color has not been acceptable without the addition of other light sources, such as incandescent lamps which have a wealth of the red energy lacking in mercury lamps.

It has long been desirable to have a mercury lamp of good color quality and still retain the high efficiency and other qualities of mercury lamps. This was made possible by Thorington's development of a new high temperature fluorogermanate phosphor which converts the wasted invisible ultraviolet energy of the quartz mercury arc into visible radiation which has most of its energy in the red spectral region. During 1950 a 400-watt color corrected mercury lamp employing this magnesium fluorogermanate phosphor made its appearance and was designated type J-H1. The phosphor was coated onto the inner surface of a specially designed "isothermal" bulb. The J-H1 produces 45 lumens per watt and is physically and electrically interchangeable with the E-H1. It can also be substituted directly for the A-H1 in most indoor applications, and, with a higher voltage ballast, in most outdoor application. (See Fig. 3.)

The J-H1 will be used principally in the lighting of large industrial areas, such as foundries, press rooms, machine shops, assembly departments, generator stations, etc. It will also be used for floodlighting and street lighting to some extent. Seaside Heights, N. J., uses it to light the ocean side boardwalks and Chicago to light flower conservatories.

All these new technical developments, therefore, have made quartz mercury arc lighting increasingly desirable for many applications and the new color corrected mercury lamps will greatly widen the acceptance of mercury vapor lighting.

(Abstract of I.E.S. 1951 Conference Paper No. 8)

Factors Affecting Performance Of Indicator Lamps

H. M. Ferree

J. D. Lash

FOR the safe, economical operation of home appliances and industrial electrical equipments, indicator lamps are becoming a "must." This paper presents data on performance factors, to aid in selections and applications of proper lamps.

Performance is affected by voltage, temperature, construction, vibration and mechanical shock.

Operating lamps at design volts is important, since a change of 5 per cent in volts can change life by 50 per cent.

"Hot shock" test data show that lamps operated considerably below their normal voltage resist shock and vibration much better. Temperatures above 350°F may affect both the solder and basing cement as well as producing adverse effects on quality.

In general, lamps designed for low voltage (6 to 8 watts) are more rugged than standard voltage lamps.

The lamps shown in Fig. 1 of the paper were "hot shock" tested. The results of this test are shown in Table I expressed as "number of shocks." These data show, in general, the greater ruggedness None of the standard voltage lamps stood up as of the low voltage lamps such as No. 44 and No. 47. well.

Authors: General Electric Co., Nela Park, Cleveland, Ohio.

TABLE I.—Hot Shock Test Results.

Lamp Number	Test Volts	Number of Shocks Minimum	Maximum	Average	Per Cent Lamps OK at 25,000 Shocks
7C7	120	800	4,300	2,650	0
10C7/1DC	120	15,000	25,000+	23,000+	80
10C7DC	120	3,000	25,000+	9,400+	20
NE-30	120	25,000+	25,000+	25,000+	100
3S6/5	120	20	1,350	690	0
6S6	120	440	7,000	2,600	0
10S6/10	250	20	330	190	0
NE-45	120	25,000+	25,000+	25,000+	100
NE-57	120	15,000	25,000+	23,000+	80
51	7.5	300	2,000	1,250	0
57	14.0	250	5,800	3,100	0
47	6.3	19,000	25,000	23,800+	80
44	6.3	25,000+	25,000+	25,000+	100
313	28.0	5,500	25,000+	19,000+	40
NE-51	120	25,000+	25,000+	25,000+	100

Glow lamps, such as NE-2 and NE-51 were unaffected by the shock test. Having no filament they are not seriously affected by voltage variations. They are rugged, long life lamps.

If the filament and mount are not designed to have the same resonant frequency, vibration at the resonant point of the mount may cause a whipping action that will seriously shorten filament life. Resonant frequencies for several lamps are given in Table II. No destructive resonant points were found in the glow lamps.

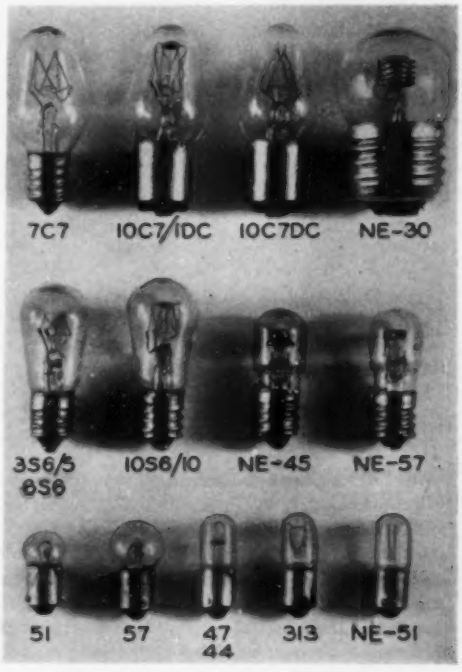


Figure 1. Lamps tested for shock and vibration.

The addition of extra supports for the filament increases ruggedness and reduces the effects of shock and vibration.

To sum up: In applications where the natural orange-red color, viewed direct, is suitable and where standard voltage is used, glow lamps are to be preferred because of their long life and resistance to shock and vibration.

When more light is required and when appreciable shock and vibration are present, provision should be made to employ low voltage, miniature lamps such as Nos. 44 and 47.

Standard voltage, small size, incandescent lamps may be used when shock and vibration are absent.

(Abstract of I.E.S. 1951 Conference Paper No. 17)

TABLE II.—Resonant Frequencies.

Lamp Number	Test Volts	Slowly Destructive	Rapidly Destructive
7C7	120	All frequencies	100, 320-370, 800, 2800-3000
10C7/1DC	120	35-130, 1600-1800	550, 2500-2700
10C7DC	120	All frequencies	180-190, 1500
NE-30	120	170-190	none*
3S6/5	120	All frequencies	310-400, 700-800, 2200, 6000, 8000, 10,000
6S6	120	All frequencies	80-120, 285-400, 750, 4600
10S6/10	120	All frequencies	200-270, 6000-7000
10S6/10	250	All frequencies	400-500, 1500-2100, 4000-5000
NE-45	120	none*	none*
NE-57	120	none*	none*
51	7.5	1100-1400, 6000-6300	800-900
57	14.0	200-410, 600-670	670-1250, 2200, 3800
47	6.3	2700-3200, 6300	1300-1500
44	6.3	2700-3300	none*
313	28.0	All frequencies	300-450, 1700-1900, 3800-4000
NE-51	120	none*	none*

*Within range of test.

R. F. Townsend

H. E. Bachman

Starting Fluorescent Lamps At Low Ambient Temperature

AS THE ambient temperature decreases below approximately 80°F, the difficulty in starting a fluorescent lamp increases. The majority of standard product fluorescent lamps, starters and ballasts are designed to give their best performance at 80°F and to provide satisfactory starting down to 50°F. Today, an increasing number of fluorescent lamps, and their related auxiliary equipment, are being used in both outdoor and indoor applications under much lower ambient temperature conditions than the recommended 50°F. For these applications we need to know the minimum ambient temperature at which lamp starting can be obtained with a particular standard product lamp and its corresponding auxiliary equipment.

Such variables as humidity, line voltage and fixture design and variations in lamps and auxiliaries, all play a part in determining the low temperature starting limit. In this paper, data and information are presented showing the effect of the more important of these variables on lamp starting. In addition, typical low temperature applications of fluorescent lamps are discussed, suggested methods are given for the selection of a lamp and auxiliary combination for startability

TABLE I.—Effect of Fixture on Test Starting Voltage.

Lamp Type	Fixture	Test Starting Voltage −10°F	+10°F	30°F	50°F
40-Watt T-12 Instant Start	4-lamp glass enclosed cylindrical vertical mounted unit	415	360	340	320
	2-lamp metal enclosed—glass face	400	350	330	320
	Isolated lamps	430	380	345	325
96" T-8 Slimline	2-lamp metal enclosed—glass face	835	750	670	635
	Isolated lamps	900	800	715	675
96" T-12 Slimline	2-lamp metal enclosed—glass face	600	525	460	435
	Isolated lamps	685	590	515	480

Authors: Westinghouse Electric Corp., Bloomfield, N. J.

TABLE II.—Relative Test Startability of Preheat Start Type Lamps at 118 Line Volts.

Lamp Type	Lamp Operating Condition	Starter Switch Type	Ambient Temperature 32°F	0°F	−10°F
40-Watt T-12 3.2 mm.	Isolated	Glow	B	A	A
	In fixture	Glow	C	C	A
	Isolated	Thermal	C	B	B
	In fixture	Thermal	C	B	B
40-Watt T-12 (LT) (Low Temperature) 2.8 mm.	Isolated	Glow	C	C	B
	In fixture	Glow	C	C	B
	Isolated	Thermal	C	C	B
	In fixture	Thermal	C	C	C
90-Watt T-17	Isolated	Glow	B	A	A
	Isolated	Thermal	C	C	B
100-Watt T-17	Isolated	Glow	B	A	A
	Isolated	Thermal	C	C	B

Designation "A" — Non-starting.
Designation "B" — Erratic starting.
Designation "C" — Reliable starting.

in an installation and suggestions are made on emergency measures which can be used in case a lamp fails to start.

For a number of instant-start type fluorescent lamps, data are given for an ambient temperature range of −10°F to 50°F, covering the test starting voltage required to start the hardest starting lamp in each group tested when the lamps were operated both in a bare lamp isolated condition and in grounded metal fixtures. A curve on the effect of variation in lamp fill gas pressure on starting is also shown.

Data are also presented showing the relative startability of combinations of various preheat-start type lamps and various types of starters at a number of low ambient temperatures. Lamps were tested both in the isolated condition and in grounded metal fixtures.

The general conclusions reached in this paper are that fairly dependable starting can be obtained with certain standard fluorescent lamps and auxiliaries at ambient temperatures appreciably lower than 50°F. Most instant-start lamps under good operating conditions will start down to an ambient temperature of 32°F, with the 40-watt T-12 instant-start lamp being useful at temperatures approaching 0°F. Preheat-start type lamps are limited in their low temperature application by the starter switch, but the 40-watt low temperature lamp is useful at temperatures down to 0°F.

(Abstract of I.E.S. 1951 Conference Paper No. 38)

Left to right:

C. H. Burns

G. A. Freeman

D. W. Rowten

Mercury Vapor Lamp Circuits

IN THE application of the mercury vapor lamp many operating problems have developed that may not be generally understood. This paper is devoted to a better understanding of mercury vapor lamps and circuits and the effect of the many variables that may be introduced.

The principal types of mercury vapor lamps are shown in Fig. 1. The various types of ballasts for multiple circuits and the circuits used with them are in Table I.

Ambient temperature affects the striking voltage of all discharge lamps, some more than others. Higher voltage is required for starting as temperature is lowered. This effect is illustrated in Fig. 2 for the 400-watt E-H1 mercury lamp.

Primary voltage taps are usually provided so

Authors: Westinghouse Electric Corp., Cleveland, Ohio and Bloomfield, N. J.

TABLE I.—Ballast Operating Characteristics.

Ballast	H.P.F. High Reactance	H.P.F. High Reactance	H.P.F. High Reactance	H.P.F. Series Capacitor	H.P.F. Lead-Lag 2-Lamp	L.P.F. Reactor	H.P.F. High Reactance	H.P.F. High Reactance	H.P.F. Lag-Lag 2-Lamp
Circuit Fig. No.	3	3	3	4	6	5	3	3	7
Type of Lamp	C-H5	E-H1 J-H1 A-H1	E-H1 J-H1 A-H1	E-H1 J-H1 A-H1	E-H1 J-H1 A-H1	A-H12	A-H12	A-H9	A-H9
Rated Lamp Watts	250	400	400	400	800	1000	1000	3000	6000
Approx. Line Watts	292	447	440	440	855	1036	1085	3165	6280
Line Voltage	120	120	115	115	115	230	120	230	230
Ballast Open Circuit Voltage	250	300	220	220	220	230	220	850	850
Approx. Line P.F. (%)	94	92	90–95	90–95	90–95	63	Over 90	90–95	90–95
NORMAL OPERATION									
Line Current (Amps.)	2.7	4.1	4.2	4.3	7.6	8.2	10.4	15.	30.
STARTING									
Line Current (Amps.)	3.4	4.4	6.8	2.9	4.5	12.	14.3	21.	42.
OPEN CIRCUIT									
Line Current (Amps.) Following a lamp failure or power interruption	3.7	6.6	4.3	3.4	1.5	0	10.6	15.4	29.6

that the ballast can be matched to the line voltage to operate lamps at normal ratings. Allowance for higher line current during the starting period should be made in circuit design. Thermal or thermal magnetic type circuit breakers should be used for circuit protection to avoid tripping out from the short duration transient line current at starting. Power interruptions or voltage dips over 15 to 30 per cent, depending on the type of ballast, will cause lamp outage requiring that several minutes elapse before it starts again.

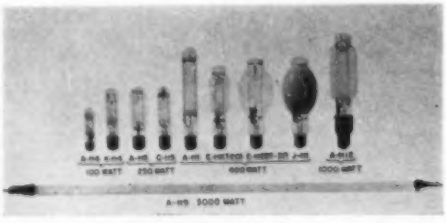


Figure 1. Mercury vapor lamps for lighting service.

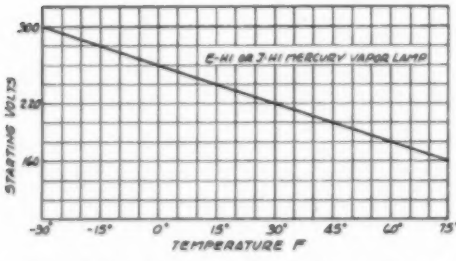


Figure 2. Relation of starting volts to temperature.

TABLE II.—Required Regulator Capacity Per Lamp.

Starting Temperature	C-H5	E-H1 & J-H1	A-H1 & B-H1
+20°F or higher	575 W	800 W	800 W
0°F	600 W	900 W	850 W
−30°F	650 W	1000 W	900 W

In series circuits the current limiting device is the constant current regulating transformer. A two winding isolating transformer is usually used with each lamp to match lamp current to line current and to limit the voltage applied to a lamp in case of power interruption or lamp failure. Series operation of mercury lamps without isolating transformers is being tried. The voltage required to start a mercury lamp is higher than its operating voltage. This requires that there be more regulator capacity than for the equivalent wattage of incandescent lamps as shown in the following table.

The power factor of a series circuit of mercury lamps is low unless corrected. Power factor correction is accomplished with a capacitor on the primary side of the constant current regulator.

Incandescent and mercury lamps may be operated on the same series circuit. The maximum number of lamps for a given regulator can be determined from the curves.

The application of mercury vapor lamps suggests an engineering analysis of the particular lamp and ballast circuit under consideration before final selection is made. It is hoped that this discussion pointing out some of the characteristics of particular lamps and ballasts will be helpful to the application engineer in planning mercury vapor lamp installations.

(Abstract of I.E.S. 1951 Conference Paper No. 31)

Low Pressure Mercury Discharges

George Meister

Thomas H. Heine

THIS PAPER is a continuation of the published work[1] on low pressure mercury discharges with inert gases and mixtures of inert gases such as neon, argon, krypton, krypton-argon and krypton-neon. The 50 per cent krypton - 50 per cent argon and 75 per cent krypton - 25 per cent neon mixtures were reported to have a maximum ultraviolet and fluorescent efficiency at an inert gas pressure of approximately 2 millimeter of mercury where the voltage passes through a minimum. The next logical gas and gas mixtures to investigate for the presence of anomalies were xenon and krypton-xenon.

All the data are taken at a constant lamp current of 500 milliamperes and at a constant temperature of 45 degrees C (about 9 microns of mercury vapor pressure) for different gas pressures ranging from 1 to 5 millimeters. Krypton at 2 millimeters gas pressure is taken as the 100 per cent reference point.

The voltage of the lamp is lowest for pure xenon and increases progressively with the pure gases of krypton, argon and neon. Krypton-inert gas mixtures have voltages intermediate between those for the two pure gases and the voltages do not show any irregularity except for the krypton-xenon mixtures.

The arc efficiency decreases rapidly for pure xenon as the pressure is increased to 5 millimeters. This large deviation was not noted with any of the other inert gases investigated. The arc efficiencies for the mixtures are intermediate between the two pure gases and have their maxima at 1 millimeter gas pressure, in agreement with data on the krypton-argon and krypton-neon mixtures.

Authors: Westinghouse Electric Corp., Lamp Division, Bloomfield, N. J.

1. Meister, G. and Heine, T. H.: "Low Pressure Mercury Discharges," ILLUMINATING ENGINEERING, Vol. XLIV, p. 681 (November 1949).

(Abstract of I.E.S. 1951 Conference Paper No. 22)

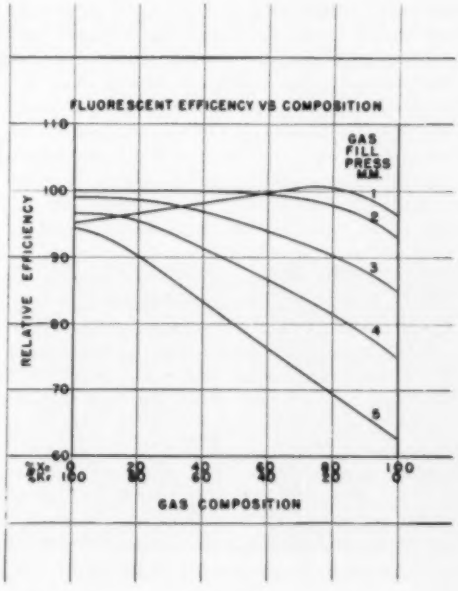


Figure 1.

From the Session on

Glare and Comfort

BCD Brightness Ratings in Lighting Practice

Sylvester K. Guth

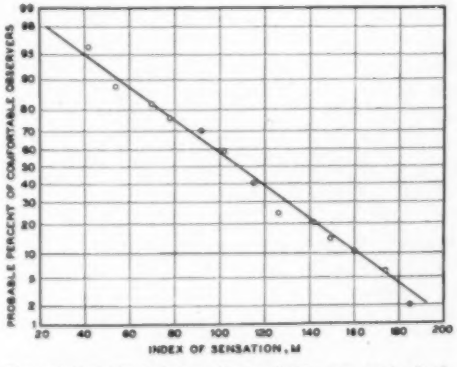
AN EXTENSIVE series of earlier investigations of the many factors which govern whether sources of brightness are comfortable or uncomfortable led to the conclusion that *a simple and practical equivalent for multiple sources of equal brightness and areas which are located above the line of vision is the total of the individual areas located at the position of the source closest to the line of vision.* This was derived from data on circular sources and was checked in a simulated visual environment. The present paper presents the results of an investigation which was designed to determine how readily this procedure could be applied to actual lighting installations.

Fluorescent lighting units were arranged in typical combinations in two sizes of experimental rooms. The method of appraising the brightnesses of these units was similar to that used in previous investigations of brightnesses at the borderline between comfort and discomfort (BCD). That is the observers who were located at one end of the room adjusted the brightness of a circular test source so that the sensation received from it was the same as the sensation received from the particular installation being compared. The index of sensation M for the test source was calculated by means of the equation.

$$M = \frac{B}{PF^{0.44}\,(Q^{-0.21} - 1.28)}$$

in which M is expressed in terms of the brightness B, size Q and position index P of the source and the adaptation brightness F. A similar calculation for the fluorescent units using the sum of the individual solid angles subtended by each of the units as Q and the weighted brightness of that part of the installation included within the visual field, yields a second value of M. The position index P was determined by the unit closest to the line of vision. The results obtained in this investigation are summarized in the accompanying table.

It is seen that the indices of sensation for each of the lighting installations and for the corresponding test source brightnesses are in excellent agreement, the average difference being about 5 per cent. They



The relationship between the probable per cent of observers who would be expected to find that the index of sensation M representing a given combination of brightness conditions to be at or more comfortable than the borderline between comfort and discomfort.

Author: General Electric Co. Lighting Research Laboratory, Cleveland, Ohio.

TABLE I.—Physical data and average indices of sensation *M* for typical fluorescent lighting installations and single sources of brightness which were judged to produce the same visual sensation.

	Experimental Condition				
	A	B	C	D	E
I. Lighting Installations					
Solid angle *Q*, steradians	0.0608	0.111	0.0228	0.0547	0.130
Position index *P*	2.3	2.3	1.5	1.5	1.5
Weighted brightness *B* of units, footlamberts	450	490	560	550	570
Adaptation brightness *F*, footlamberts	40	70	35	50	70
Index of sensation *M*	74	106	84	117	226
II. Circular Test Source					
Observed brightness *B*, footlamberts	1570	3050	1920	3100	6950
Index of sensation *M*	70	106	91	125	243
Difference between indices of sensation *M*, per cent	4.8	0	8.3	6.4	7.0

indicate that the proposed method of applying the BCD concept of adding the individual solid angles and using the position index of the source closest to the line of vision produces values that agree with experimentally determined indices of sensation.

Since the BCD concept seems to be readily applicable to lighting installations, it appears desirable to be able to assign some significance to numerical values of the index of sensation. An analysis of data obtained with a group of 50 observers indicates that the distribution of BCD brightnesses (and the corresponding indices of sensation) selected by them followed a normal probability function. From these data the relationship was developed to illustrate the number of observers who indicated the index of sensation *M* to be greater than a specific value for a given source brightness. This relationship, shown in the accompanying chart, can be used to predict the probable per cent of a given group who would be expected to judge a specific combination of source size, position and brightness and the adaptation brightness to be at, or more comfortable than, the borderline between comfort and discomfort (BCD). For example, if *M* is equal to 160, only about 10 per cent of a group could be expected to be comfortable. On the other hand, if *M* is about 40, 95 per cent would be expected to be comfortable.

(Abstract of I.E.S. 1951 Conference Paper No. 10)

The Effect of Spectral Composition of Illumination On Visual Performance

D. Y. Solandt

R. E. White

MANY STUDIES on the visual acuity of the eye using illumination of various colors have been reported. Konig,[1] Roaf[2] and others concurred in the finding that visual acuity is at its lowest value using blue light and is lower for red light than for radiations around the middle of the visible spectrum. Schlaer, Smith and Chase,[3] using the Landolt C test character, obtained substantially the same acuity using white, red, yellow, and blue lights. Hartridge[4] found visual acuity to vary but little when lights of different colors were used.

The results of these experiments using, in the main, single "pure" or "spectral" colors (monochromatic illumination) give no information concerning the visual effectiveness of mixtures of such colors. Allen and Schwartz[5] have pointed out that light of one color may stimulate or inhibit the response to another color. Thus, it is possible that any mixture of spectral colors may give rise to complicated inter-actions which cannot be predicted on the basis of studies using monochromatic illumination. This hypothesis receives some support in the findings reported by Simonson and Brozek[6] and by von Bahr.[7]

The present work was undertaken to assess separately and compare the visual effectiveness of white

Authors: Dept. of Physiological Hygiene, School of Hygiene, Univ. of Toronto, Toronto, Canada. Work supported by a grant from the Research Fund, Illuminating Engineering Society.

light produced by a source with a continuous spectrum and white light produced by mixing complementary spectral colors of narrow band width with their relative intensities adjusted to yield white light.

Visual acuity was measured using two mixtures of monochromatic lights adjusted to give the sensation of white light and the results were compared with those obtained using the white light from a concentrated (zirconium) arc lamp, and from a fluorescent (white or daylight) lamp.

Three projection lanterns were designed and built, each one housing a 100-watt concentrated (zirconium) arc lamp and equipped with interchangeable monochromatic filters. These lanterns were arranged to cast their beams on the same area of the rear surface of the transparent test object. The lanterns could be used singly (monochromatic illumination), or in pairs (dichromatic), or the three (trichromatic illumination) lanterns could be used simultaneously. Cenco filters were employed to give monochromatic lights of the following colors and band widths: (i) yellow 540-670, (ii) blue green 450-600, (iii) orange 560-700, (iv) green 500-600, (v) blue 420-510 mu.; (i) and (ii) were employed to produce the dichromatic, and (iii), (iv) and (v) the trichromatic illumination. Two other types of illumination were supplied by (a) a single 100-watt concentrated (zirconium arc lamp, and (b) a circline fluorescent lamp (white). The spectral distribution curve for the zirconium arc lamp is continuous, and that for the fluorescent lamp shows peaks of the mercury spectrum superimposed on the relatively continuous spectrum of the various fluorescent materials in the phosphor. That of the dicromatic illumination showed two peaks and the trichromatic three, in accordance with the filters used.

TABLE I.—Latin Square.

	1	2	3	4
a	A	B	C	D
b	B	D	A	C
c	C	A	D	B
d	D	C	B	A

Legend:
Subjects: a, b, c, d
Order of Presentation: 1, 2, 3, 4
Fluorescent lamp: A
Yellow (540-670 mu) and blue green (450-600 mu), Dicromatic mixture: B
Zirconium arc lamp: C
Orange (560-700 mu), green (500-660 mu) and blue (420-510 mu) Trichromatic mixture: D
The order of presentation of illuminations is read from left to right in each row.

The test objects were photographically produced in the form of lantern slides with the Landolt broken ring as the test character, the break or gap being the point of critical detail. The slides were made in a descending series with respect to the size of the test character. The largest test character was 2.5 mm. high with a gap of 0.63 mm. which was reduced serially so that the gap dimension decreased by approximately 0.04 mm. for each subsequent slide of the series.

The viewing screen was an opal glass plate installed as a window in the wall which separated the subject from the light sources. One slide at a time was placed in the special carrier inserted in the center of the round door covering the viewing screen. The resulting circular aperture was 52 mm. in diameter and was viewed using both eyes, with natural pupils, at a distance of three meters. The brightness of the test object set up in this manner was standardized at ten footlamberts for the area in and around the test character which itself appeared black with a bright gap (critical detail) and central region. The spectral energy at the front surface of the test object was measured over the visible spectrum with an adjustable monochromatic photometer (the Cenco-Sheard spectro-photelometer) in conjunction with a direct current amplifier and galvanometer. The brightness of the major surround (visual field around the test object) was kept constant at two footlamberts.

Each of four subjects was asked to identify which of eight possible positions was occupied by the gap in the *C* carried by the test object as the slides were changed to reduce the visual angle subtended by the test character. Four spectrally different types of illuminations were thus tested. A four by four Latin square design, as shown in Table I, was set up for each experiment and resulted in a different order of presentation of the

TABLE II.—Analysis of Variance.

	d.f	Sum of Squares	Mean Square	f ratio	
Subject	3	.016054	.005351	5.33*	significant
Order	3	.003322	.001107	1.10	not significant
Illumination	3	.001492	.000497	0.50	not significant
Error	6	.006020	.001003		
Total	15	.026888			

	A	B	C	D
Means	.392	.406	.415	.416

*f ratio at five per cent point: 4.76.

four types of illumination to the four subjects. This technique balances out the effects of learning and unknown extraneous variables which might alter from session to session. The method permits the separate treatment of the data for the assessment of order effects, illumination effects and inter-subject differences using the "Analysis of Variance."

The "Analysis of Variance," as summarized in Table II, showed no significant difference in visual acuity with the four spectrally different types of illumination tested. The order of presentation showed no significance, while, as would be expected, inter-subject differences were significant. These results suggest that the spectral composition of white light is not a factor in visual acuity. An extension of the study described is now being carried out to further test the validity of this generalization.

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(Abstract of I.E.S. 1951 Conference Paper No. 36)

Work, Vision and Illumination

Ernst Simonson

Josef Brozek

APPROACHES and results concerned with the effect of illumination on visual performance as background for establishing illumination codes, are critically reviewed. The available codes lack for the most part proper experimental basis, which results in largely arbitrary recommendations. This is demonstrated by the trend in illumination codes in the past decades and by the marked discrepancies between the present American and British illumination codes. The approximately five-fold increase in recommended illumination levels from 1910 must be explained by absence of adequate data and by a different interpretation of the available results. The British recommendations refer to 90 per cent of attainable performance and are substantially lower than the American codes referring to "ideal" illumination conditions which are frequently interpreted as the *maximum* illumination that can be provided. The American codes give actually the upper limit of inadequate illumination. The underlying principle of the American codes ignores the fact that with the increase of illumination an optimum is reached in performance and fatigue trends of visual functions. It is suggested to give both lower and upper limit of the range of acceptable illumination in future codes.

The approaches to the study of illumination and visual work are subdivided as follows:

(1) Brief Tests (a) Visibility—visual acuity, visibilometer; (b) Visual Performance—recognition of details
(2) Fatigue Trends in Visual Functions
(3) Fatigue Trends in Non-Visual Functions
(4) Industrial Work Performance
(5) Miniature Work Situations
(6) Practical Experience.

The advantages and limitations of each approach are critically discussed with reference to examples of experimental results. The most frequently used approaches to arrive at recommendations are (1) and (6) but unfortunately, they are the least reli-

Authors: The Laboratory of Physiological Hygiene, University of Minnesota, Minneapolis, Minn.

able. There is good evidence that prediction of prolonged performance from brief tests is questionable. Practical experience is valuable but does not provide a proper scientific basis. Theoretically, fatigue trends in visual functions should provide a reliable definition of visual fatigue and a suitable basis for illumination codes, but the actual material is still scanty and, in general, disappointing. Fatigue trends in non-visual functions, such as blinking rate, heart rate, and muscle tension, as well as industrial work performance, are easily interfered with by numerous incidental factors and conditions, such as emotion or change of motivation. Miniature job situations reproduce essential features of industrial work under controlled laboratory conditions. In the work of the authors, performance in a miniature job situation was shown to be superior as criterion for illumination conditions to most of the other visual tests simultaneously applied. A disadvantage of miniature job situations is the fact that they often require an elaborate and costly set-up. As an ideal approach for future research the combination of miniature job situations with fatigue trends of visual functions, and possibly non-visual functions, together with subject ratings, is recommended. There is an urgent need for further research and cooperation of the various groups interested in vision and visual work.

(Abstract of I.E.S. 1951 Conference Paper No. 35)

Kirk M. Reid

D. A. Toenjes

Appraisal of Discomfort Glare On Lighted Streets

IS THERE a relation between the discomfort caused by glare from street lights and the vertical footcandles incident on the eye of the motorist? If so, is the relation sufficiently definable to be useful in predicting the degree of comfort to be expected from a proposed street lighting installation? And what is the relation between discomfort and the interference with seeing caused by such glare?

Too little is known quantitatively of factors affecting discomfort glare in street lighting. Hence a program of studies of this subject has been outlined and is sponsored by the Research Subcommittee of the I.E.S. Committee on Street and Highway Lighting. The program includes both laboratory and field studies which, in later steps, approach similar conditions. The Putnam-Faucett paper (see page 474) reports the beginning of the laboratory work. The first field studies are reported herein.

Procedure.—Appraisals of discomfort glare were made while driving under 31 widely diversified street lighting installations in Cleveland. There were 10 "glare appraisers"—from Case Institute of Technology, the Nela Park Engineering Depart-

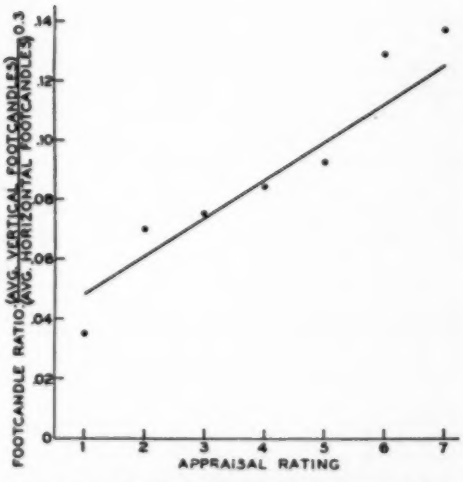

Figure 1. Cleveland arterial test streets. *Averages* of the footcandle ratios for *each individual* comfort-discomfort appraisal rating number, shown as a function of the appraisal rating numbers.

Authors: Engineering Department, Lamp Division, General Electric Company, Nela Park, Cleveland, Ohio.

TABLE I.—Comfort-Discomfort Appraisal Rating Numbers.

Pleasant—not noticeable as glare	1
Barely comfortable	2
Borderline between comfort and discomfort	3
Mildly uncomfortable	4
Uncomfortable	5
Sharply uncomfortable	6
Intolerable	7

ment, the Cleveland Electric Illuminating Company and the City of Cleveland. Measurements were made throughout each installation, with the Taylor-Pracejus Illumination Recorder, of horizontal illumination near the pavement and of vertical illumination at the eye position of a representative motorist. Street Lighting Evaluator measurements of pavement brightness, obstacle brightness, and veiling glare were also made.

Summary of Conclusions

1. The great majority of our street lighting is glaring, in varying degree from mildly uncomfortable to sharply uncomfortable.

2. There appears to be a general relation between comfort-discomfort appraisals (see Table I) and *vertical* footcandles on the eye provided *horizontal* footcandles on the pavement are taken into account as an index of field brightness. See Fig. 1.

3. Similarly, there appears to be a general relation between comfort-discomfort appraisals and Evaluator measurements of veiling glare, provided pavement and obstacle brightnesses are taken into account as an index of field brightness. See Fig. 2.

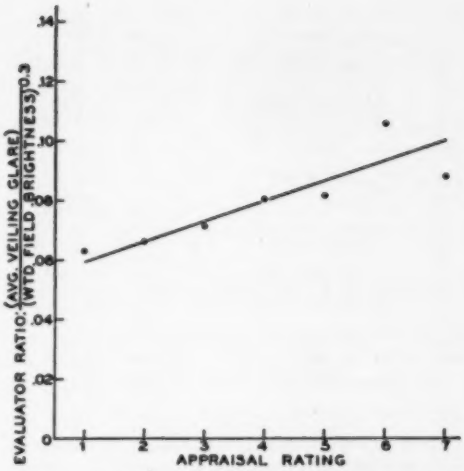

Figure 2. Cleveland arterial test streets. *Averages* of the Evaluator ratios for *each individual* appraisal rating number, shown as a function of the appraisal rating numbers. The weighted field brightness, in the ordinate, is the sum of 70% of the average pavement brightness and 30% of the average obstacle brightness.

4. The results of this study hold promise that factors affecting discomfort glare in street lighting *can* be dealt with quantitatively.

(Abstract of I.E.S. 1951 Conference Paper No. 28)

Seeing Against Headlamp Glare

Val Roper

G. E. Meese

EVEN the "experts" do not agree as to the best answer to the motor vehicle headlighting problem. That there still is a problem is attested by the amount of tinkering with factory-installed headlamps with object of alleviating glare. Undoubtedly glare is the attribute of motor vehicle headlamps of which people are most conscious. However, in their attempts to overcome the annoyance of glare many designers overlook the fundamental requirement that headlamps should provide seeing distances somewhat in excess of stopping distances for normal driving conditions. Unfortunately even the modern sealed beam headlamps do not provide such seeing distances for many regularly encountered driving situations. The

Authors: General Electric Company, Lamp Department, Nela Park, Cleveland 12, Ohio.

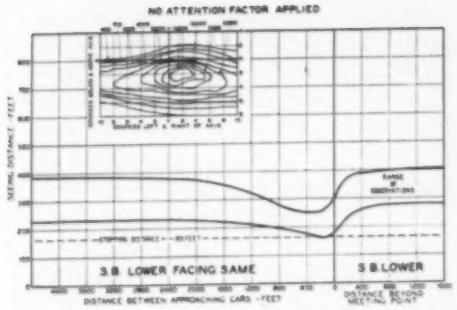
NO ATTENTION FACTOR APPLIED
SEEING DISTANCE - FEET
S.B. LOWER FACING SAME
S.B. LOWER
DISTANCE BETWEEN APPROACHING CARS - FEET
DISTANCE BEYOND MEETING POINT

Figure 1. Seeing distances while driving on two-lane road. Road width: 21 feet. Car speed: 40 MPH. Obstacle: 16 inches square with 8.5 per cent reflectance.

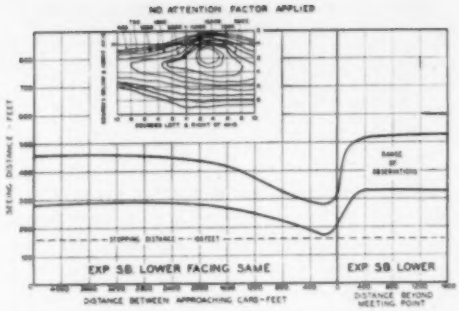
NO ATTENTION FACTOR APPLIED
SEEING DISTANCE - FEET
EXP SB LOWER FACING SAME
EXP SB LOWER
DISTANCE BETWEEN APPROACHING CARS - FEET
DISTANCE BEYOND MEETING POINT

Figure 2. Seeing distances while driving on two-lane road. Road width: 21 feet. Car speed: 40 MPH. Obstacle: 16 inches square with 8.5 per cent reflectance.

reasons (aside from physiological factors such as poor eyesight and fatigue) are insufficient intensities of light directed far enough ahead, and veiling glare from approaching vehicles.

The chief objective of the research reported in this paper was to determine whether any practical combination of upper and lower beam patterns properly used could be evolved which would close up present gaps between stopping and seeing distance values. The use of the new Taylor-Pracejus Illumination Recorder facilitated seeing distance measurements with observer-drivers, and provided a simultaneous record of footcandle-intensities at the driver's eye from opposing headlamps.

Fig. 1 shows a seeing distance curve for the condition of approaching and proceeding beyond an oncoming vehicle travelling at the same speed and with the same sealed beam headlamps of current manufacture. Fig. 2 shows a similar curve with an experimental lower beam. These data indicate that an alteration of the lower beam providing higher intensities nearer the top right side of the beam pattern will produce increased seeing distances despite a moderate increase in glare values.

Additional data presented in the paper show the relation between footcandles at the eye from opposing headlamps and per cent clear road seeing distance. These should be of assistance for the calculation of the amount of separation required between lanes to permit the use of an upper beam at all times.

(Abstract of I.E.S. 1951 Conference Paper No. 30)

The Evaluation of Visual Comfort Data

H. L. Logan

A. W. Lange

THIS PAPER attempts a workable correlation of Holladay's, Luckiesh and Guth's, Harrison's, Moon and Spencer's and Petherbridge and Hopkinson's data on visual comfort.

BCD Curves.—Fig. 1 shows curves of equal response (referred to in the literature as "BCD" curves) prepared from the data of the investigators mentioned above, and plotted in relation to source brightness and source size. The brightness is in footlamberts and the source size ("Q") is in percentage of the field of view.

The 10-Footlambert Threshold.—The Holladay,

Authors: Sylvania Electric Products, Inc., New York, N. Y.

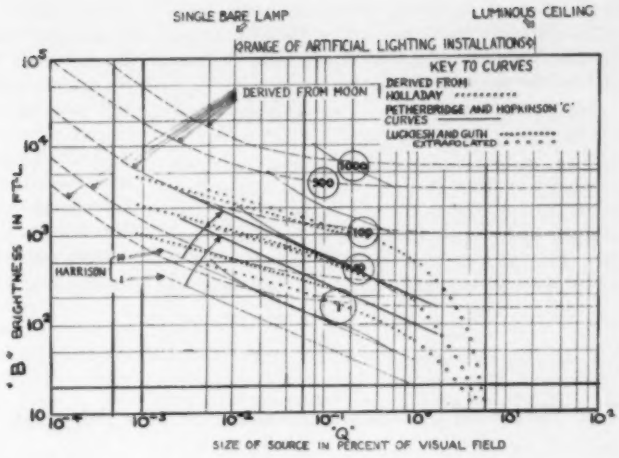

Figure 1. Summary of visual comfort evaluation data. The encircled numerals are footlamberts and locate the various approximations of comfort-discomfort thresholds for the adaptation levels shown.

Luckiesh and Guth, Petherbridge and Hopkinson, and Harrison adjusted 10-footlambert threshold curves agree closely between $Q = 0.04$ and $Q = 1$ (Fig. 1). The theoretical Moon-Spencer 10-footlambert curve passes through the other curves at the point where they also all agree, viz., $Q = 0.4$, so this point seems well established. However, the divergencies between the curves at the other levels prevents a satisfactory determination of their location without additional data.

The 1000-Footlambert BCD Threshold.—The location of the 1000-footlambert threshold was established from data in the records of natural lighting investigations made by the writer over a period of fifteen years.

Location of the BCD Thresholds.—As the various workers are in close agreement on the 10-footlambert threshold, and as the downward extrapolation of the Petherbridge and Hopkinson 10-footlambert curve met theoretical objections the others did not meet, the P & H curve was adopted for this level. The principle of logarithmic relationship between the various levels was established by Holladay, and confirmed by succeeding investigators, even though they disagreed as to the precise logarithmic spacing. Therefore, as the evidence for

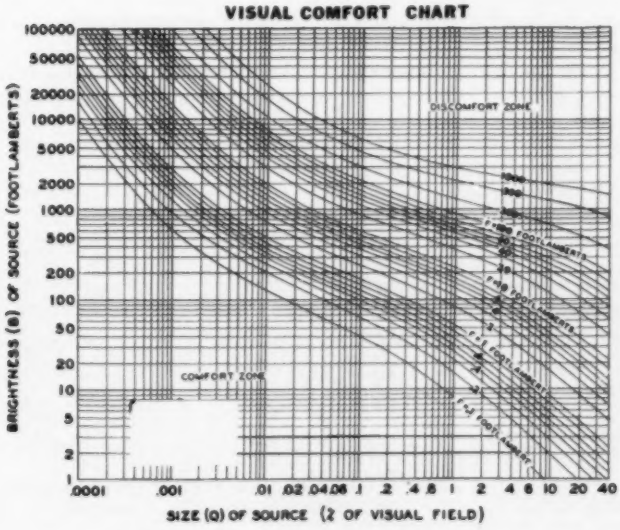
VISUAL COMFORT CHART
BRIGHTNESS (B) OF SOURCE (FOOTLAMBERTS)
SIZE (Q) OF SOURCE (% OF VISUAL FIELD)
DISCOMFORT ZONE
COMFORT ZONE

Figure 2. Observations taken from fields of view in nature to establish the $F = 1000$ Ft-L threshold.

the location of the 10-footlambert and the 1000-footlambert thresholds was strong, the logarithmic spacing that was dictated by fixing these two was adopted for the other thresholds.

Visual Comfort Chart. — The resulting visual comfort chart is given in Fig. 2.

When an engineer using the Luckiesh-Guth position indices equates the different glare brightnesses in the field of view to one glare source on the line of sight, and locates this figure on the visual comfort chart he will find the glare situation interpreted as a percentage of the BCD threshold for the field of view in question. If the engineer will then locate this "percentage of BCD" figure on the "Plot of the Scatter of Observer's Comfort-Discomfort Responses," (given in the paper), he will learn what percentage of observers are likely to give a comfort response.

This technique permits an engineer to pre-determine the probable comfort responses of the users of a proposed lighting installation when it is in the drawing board stage, and a practical example is worked out in the paper.

(Abstract of I.E.S. 1951 Conference Paper No. 20)

The Threshold of Discomfort Glare at Low Adaptation Levels

Russell C. Putnam

Robert E. Faucett

THIS PAPER presents a fundamental study of the borderline between visual comfort and discomfort when the glare source is very small and the eye is adapted to low brightness levels.

The recent work on the borderline of comfort-discomfort (BCD) by Luckiesh and Guth is pertinent to this study. Their work deals with adaptation brightnesses of from 1.0 to 100 footlamberts and glare source sizes from 0.0001 to 0.013 steradian which are in the ranges of ordinary indoor seeing tasks. The investigation discussed in this paper follows their laboratory technique very closely but deals with adaptation brightnesses of 10 to 0.001 footlamberts and glare source sizes from 0.0011 to 0.000001 steradian which approximate the conditions found in street lighting. The 10 and 1 footlambert adaptation levels are common to the two investigations.

For a glare source on the line of sight and of the same size as that used by Luckiesh and Guth (0.0011 steradian) the comparison of results of the present study with the extrapolation of Luckiesh and Guth's work shows close agreement (Fig. 1). The curves are parallel and can be explained by the same empirical equation, $B = CF^{0.44}$ where B represents the brightness of the glare source at the borderline between comfort and discomfort, F represents the brightness of the general field of view to which the eyes are adapted and C is a constant. The important and highly significant aspect of the comparison of the results of these two investigations is that the experimental curves are parallel and the exponent of F is the same. This shows that the two independent groups of observers, which differed greatly in background and experience, appraised the change in BCD with change of adaptation brightness at exactly the same rate.

When smaller glare sources are investigated and the results plotted for a constant adaptation bright-

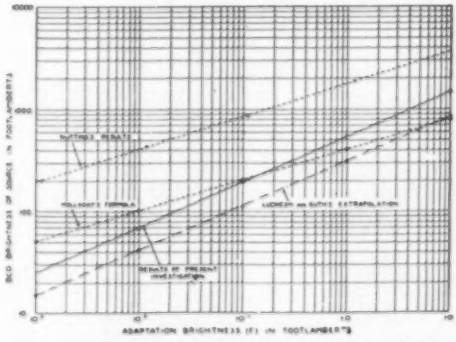

Figure 1. Comparison of the results of various researches for a source size (Q) of 0.0011 steradian.

Authors: Russell C. Putnam, Case Institute of Technology, Cleveland, Ohio; Robert Faucett, C.A.A. Technical Development and Evaluation Center, Department of Commerce, Indianapolis, Indiana.

ness, the BCD brightness does not vary linearly as would be indicated by extrapolation of previous investigations. As the glare source becomes smaller than 10^{-5} steradian, the BCD brightness of the glare source becomes greater at an increasing rate (Fig. 2).

It is significant that the curvature of BCD brightness of source curves upwards for small source sizes in this investigation and downward for large source sizes as reported by Luckiesh and Guth whereas in the region where the two overlap the results are straight lines with the same slope. This is in agreement with practical experience that considerable brightness can be tolerated without discomfort if the sources are small whereas the brightness must be kept relatively low for large light sources if comfort is to be maintained.

These factors of small source size and low adaptation brightness are important in seeing on the highway at night. In order to apply these data completely and practically many other factors, such as the effect of a number of sources, position of the sources in the visual field, non-uniform adaptation brightnesses, etc., must be investigated and integrated with these results.

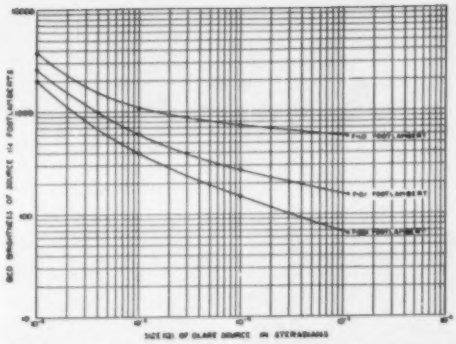

Figure 2. The relationship between BCD brightness and size of source for three different adaptation brightnesses. The sources are located on the line of sight.

(Abstract of I.E.S. 1951 Conference Paper No. 27)

For Discussion of I.E.S. Conference Papers

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Discussion Organizers

Monday afternoon, August 27

General Technical Session — Papers Nos. 2, 7, 13, 24, 26, 39 — R. D. Bradley, Day-Brite Lighting Inc., 5411 Bulwer Ave., St. Louis, Mo.

Sources Session — Papers Nos. 6, 8, 17, 22, 31, 38—Kirk M. Reid, General Electric Co., Nela Park, Cleveland, Ohio

Tuesday morning, August 28

General Technical Session — Papers Nos. 19, 21, 23, 37, 40 — Robert R. Wylie, Sylvania Electric Products Inc., 1740 Broadway, New York, N. Y.

Aviation Session — Papers Nos. 41, 42, 43 — D. C. Miller, General Electric Co., Nela Park, Cleveland, Ohio

Tuesday afternoon, August 28

Glare and Comfort Session — Papers Nos. 10, 20, 27, 28, 30, 35, 36 — H. P. Steele, Benjamin Electric Mfg. Co., Des Plaines, Ill.

Wednesday morning, August 29

General Technical Session — Papers Nos. 1, 3, 5, 12, 14, 16, 33 — Howard L. Wright, Curtis Lighting of Canada, Ltd., 195 Wicksteed Ave., Leaside, Toronto, Ont.

Residence Lighting Session — Papers Nos. 4, 18, 25, 29—Caroline E. Horn, Electrical Testing Laboratories, Inc., 2 East Second Street, New York, N. Y.

Thursday morning, August 30

Street Lighting Session — Papers Nos. 11, 15, 32, 34 — Rolland M. Zabel, Westinghouse Electric Corp., Bloomfield, N. J.

Thursday afternoon, August 30

Government Session — Papers Nos. 44, 45, 47— Paul H. Hildebrand, Pennsylvania Power and Light Co., 901 Hamilton St., Allentown, Pa.

From the Session on

Aviation Lighting

Fred R. Brown

David Alsher

Visual Problems In Aircraft Lighting

CONSIDERABLE development in the field of interior and exterior aircraft lighting has occurred during the past few years. The psychophysiological aspects of the pertinent visibility problems have been studied in our laboratory to provide information on design characteristics compatible with the human requirements.

In the case of cockpit lighting, investigations were conducted with the view of achieving maximum legibility and comfort, and, at the same time, preserving dark adaptation. The relative merits of red, indirect, false panel lighting and the standard ultra-violet floodlighting for instrument dials were compared for interference with dark adaptation. At operationally useful levels of brightness there was quicker detection of targets after exposure to the red panels. Data obtained with a Hecht-Schlaer Adaptometer also showed that, under these conditions, dark adaptation was better preserved by red lighting. Preference by a majority of pilots in a joint Navy-Air Force evaluational flight tour also was in favor of red lighting.

Development, then, of aircraft cockpit lighting proceeded in terms of red-filtered incandescent lighting. Studies were made of legibility with minimum amounts of light flux. Data showed that indirect lighting was preferable to floodlighting for the attainment of optimum legibility with the least possible amount of flux. A form of indirect lighting in the case of panel instruments is the localized lighting of the dial face by shields containing small red bulbs. For control panels plastic plates with negative prints in black applied over translucent white layers allow for markings to appear white on a black background in daylight and for trans-illumination with red light at night.

Another approach toward achieving optimum legibility was in improving design of markings, letters and numerals. Size, brightness and form were studied in a series of tests conducted with subjects in a special light-tight enclosure. A series of numerals incorporating experimental findings as

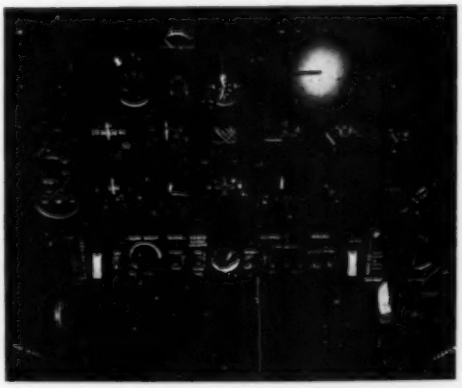


Figure 1. Aircraft Cockpit Instrument and Control Panels. Instruments are illuminated by individual lighting shields. Control panel is transilluminated. A small amount of general floodlighting highlights the knobs and switches.

NOTE: The views and opinions expressed in this paper are those of the authors and do not necessarily represent those of the Department of the Navy.

Authors: Aeronautical Medical Equipment Laboratory, Naval Air Experimental Station, Philadelphia, Pa.

to optimum style, width to height ratio, and stroke-width to height ratio were devised. Evaluation tests indicated them to be more legible than two other widely accepted styles not only for transillumination use but also for daylight. Subjective tests were run on the effect of red floodlighting supplementing high contrast indirect red lighting. A feeling of comfort resulting from improved orientation in the cockpit was demonstrated to result when a small amount of red floodlighting of the cockpit is employed in combination with transillumination of the cockpit displays at a sufficient brightness, about 40 micro-lamberts. A second major phase of aircraft lighting is that of exterior lighting. A series of experiments included simulated flights in Link Trainers and actual flights for study of autokinetic effects, recognition of aircraft attitude, etc. Based on these experimental results, a pattern of wing tip, tail and fuselage lights was devised. Formation Flying presents a special lighting problem in military aviation. Special lighting for structural delineation has been tested and recommended for this purpose.

In our laboratory stellarium studies are being conducted to furnish psychological data on recognition time for exterior lights against star backgrounds. The data will be used to recommend flash rates and intensities for exterior lights, especially for those used in high speed aircraft where visual detection problems are critical.

Landing signal lights for indication of an aircraft's attitude have been devised to aid the Landing Signal Officer on a carrier deck in interpreting the approach of the aircraft during both day and night. Red, amber and green lights furnish indicatioins of the aireraft's approach condition. Intensities, beam angles and color distinctiveness of the approach light are being studied and improved models are being developed.

(Abstract of I.E.S. 1951 Conference Paper No. 41)

Visual Aids for Airport Ground Traffic Control

Martin A. Warskow

AS STEADY progress is made toward accomplishing all weather flying on a routine basis, it becomes apparent that more guidance must be provided to aircraft maneuvering on the airport surface. The pilot must be enabled quickly to guide the aircraft off the runway under the severe seeing condition of low visibility. He must then be able to navigate to his destination (sometimes two or more miles away over winding taxi routes) with a minimum of instruction from the control tower operator.

Electronic aids will be used to detect and track the location of aircraft on the airport surface, but visual aids can indicate the taxiway intersections with the runway, can provide navigational guidance along the taxiways, and can provide traffic control signals. This paper concerns itself with the immediate need of taxiway entrance signs, and route marking signs.

A basic factor in the design of both taxiway

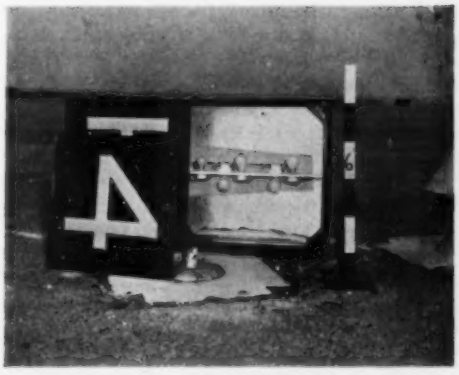


Figure 1. Interior of experimental taxiway entrance sign.

Author: Airport Engineering Division, The Port of New York Authority.

entrance signs and en route signs is the legibility distance required. A conservative analysis of aircraft stopping distances and aircraft taxi speeds establishes that the minimum legibility distance required is 400 feet. This legibility can be provided with 10-inch letters.

Since the most urgent need for visual aids in ground traffic control is for taxiway entrance signs, experimental work was started on this problem. In addition to legibility, here an easily discernible target is required. The size of the entrance sign decided upon for experimental purposes at New York International Airport permitted the use of characters 18 inches in height which should serve well for attention catching.

Signs of the neon type, background lighted type, and lighted plastic letter type were installed. Day and night observations were made by many individuals including the writer. The night visibility problem is complicated by the fact that the entrance signs must be observed and read "through" a row of high intensity runway lights whose intensity may vary from 100 to in excess of 20,000 candlepower.

From these experiments, several conclusions were drawn as to the type of sign, and its construction and installation. The accompanying photo illustrates the type of sign found best considering all factors. Additional experiments are currently under way on the use of reflective type markers.

Since the taxiway entrance and en route signs are navigational aids, they must be standardized on a nation-wide basis before any widespread local installations can be made. The establishment of these standards is the responsibility of the Civil Aeronautics Administration. The progress towards establishing these standards was discussed at the conference by Mr. B. A. Hemelt as a supplement to this paper. The proposed route marker systems are being installed, tested, and evaluated at the Civil Aeronautics Technical Evaluation and Development Center, Indianapolis.

(Abstract of I.E.S. 1951 Conference Paper No. 42)

Are Present Lighting Aids Adequate For Private Flying?

Robert C. Blatt

MOST ARTICLES published and technical papers presented on the subject of aviation ground lighting deal with the lighting of the large air transport type of military landing fields. They deal with the more glamorous side of airport lighting—high intensity approach and runway lighting —landings being made by large transport planes under poor visibility and low ceiling conditions.

Apparently very little consideration or thought has been given the private pilot in a small single engine personal type airplane who has ventured "cross country" after nightfall. Or perhaps he couldn't find the airport before darkness set in? Are there sufficient ground lighting facilities provided for him?

Personal plane pilots are being driven away from the large well lighted airports by heavy traffic and high landing fees. They are being forced to seek night landings at the small personal flying airports —few of which have any lighting whatsoever. Most of those that are lighted have makeshift, "Rube Goldberg" or antiquated equipment.

In an attempt to get the private flyer's side of this picture a survey was conducted by the author among 50 private flyers who had done considerable night flying, representing a total of 13,137 hours (night flying) by those who responded. 22 per cent had more than 500 hours of night flying; 48 per cent had from 100 to 500 hours and 30 per cent had 100 hours or less of night flying.

The results of this survey indicated that present lighting aids are definitely *not* adequate for *private* flying.

In spite of the fact that 93 per cent of the private flyers said that airway beacons were helpful to them, the CAA has already extinguished about half of the 2000 enroute and intermediate field beacons as of January 1951. The CAA policy is

Author: Associate Editor, *Electrical World*.

to retain short-interval beacon light spacing in mountainous terrain and in other hazardous areas, while increasing the distance between lights in level terrain. The CAA's attitude is that the excellent radio navigational aids now available and the large number of airport beacons have made night navigation in level terrain relatively easy and safe for any pilot using a minimum of radio equipment.

Although the standard CAA airport beacons were considered adequate by most of the private flyers, a large number favored the Army split beam type airport beacon having a greater duration of white flash.

Airport wind sock and wind tee lighting was generally considered poor while wind tetrahedron lighting was rated high.

The lighting at large terminal airports was considered adequate by 78 per cent and the following types of field lighting were favored in this order:

First—High intensity runway lights
Second—Cone mounted strip lights
Third—Flush runway lights
Fourth—Boundary lights
Fifth—Floodlights
Sixth—Reflective markers

For small private flying fields, the survey respondents indicated an average of only six fields each they had visited having any field lighting *whatsoever* and an average of only two fields each having *adequate* lighting. They said that if these small private flying airports were adequately lighted for night flying, they could get an average of 46 per cent *more utility from their planes.*

Lighted directional taxiing signs at large terminal airports were wanted by 93 per cent and 82 per cent said that the blue taxi lights were helpful. Personal aircraft instrument panel lighting was found inadequate by 63 per cent and 37 per cent said that their navigation lights were not adequate. It was though by 45 per cent that navigation lights should flash. It was the opinion of 70 per cent that landing lights *were* adequate but that they could always be more powerful. Cabin lights were considered adequate by 67 per cent—but only on the 4-5 place planes.

Most of the flyers had no experience with aircraft flares. About 30 per cent considered them adequate, but only if the pilot was thoroughly familiar with the proper emergency technique in using them. Many thought they were too dangerous to keep in the plane.

Conclusion.—The whole future of private flying depends on getting away from the "sunset jitters." The airlines didn't achieve real utility until they started flying at night. The same applies to private flying. Adequate universal airport lighting is one of the three necessary steps—(1) Twin engine planes, (2) Simplified instrument flying and (3) Good lighting.

Figure 1. Homemade strip lights installed at small private flying airport at Deer Park, L. I., N. Y. consist of 10-watt lamps in fruit jars set on peach baskets. Rubber covered wire feeding lights is laid on turf.

Figure 2. Floodlight on airport building roof (at left) plus light signal gun comprises only field lighting at Christie Airport (N. Y.). Note *unlighted* wind sock.

The CAA has established standards for adequate lighting at private flying type airports and a number of manufacturers have made suitable equipment available. Aside from the safety angle, there are many benefits to be derived from adequate small airport lighting — more utility for private flyers; more demand for private type airplanes; more business and increased profits for small airport operators.

It is strongly urged that private airport operators, as well as municipal, state and federal agencies, provide more and better lighted airports for personal plane flying.

(Abstract of I.E.S. 1951 Conference Paper No. 43)

From the Session on

Street Lighting

How to Measure Pavement Surface Reflectances

J. O. Kraehenbuehl

IT IS desirable to develop some form of objective specification for pavement surfaces, whether used in street and highway lighting or for airports. To prepare such a specification it is necessary to have some means by which rapid measurements may be made of the character of emission radiated from the surface when it is illuminated by a light source. Measurements must be made in three dimensions with a reasonable degree of speed and accuracy.

Author: University of Illinois, Urbana, Illinois.

Fig. 1 shows a reflectometer built for making the measurements of a surface finish. A sample of pavement (C), either new or worn, measuring 12 inches in diameter with a thickness equivalent to that of the pavement, is removed from the installation. The sample is leveled at the datum plane of the equipment having been adjusted for elevation by the screw (I). The light source (B), a 600-w military spotlight, is positioned on the specimen by the optical system (J) which is then removed.

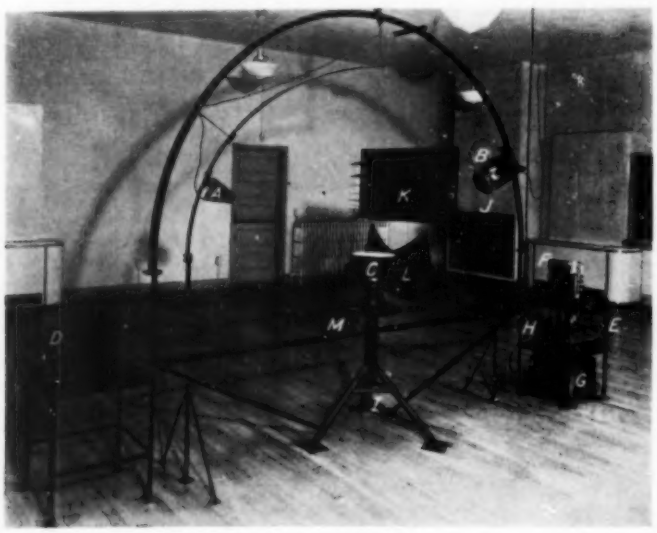


Figure 1. Pavement Surface Reflectometer.

The arm carrying the cell (A), whose solid angle subtension is restricted by baffles, is rotated by the motor (D). As the cell moves in a horizontal plane at any latitude a record is made on an automatic recording potentiometer (F). The voltage on the lamp is controlled by powerstats and regulators (H) for adjustment to 20 volts and constancy. The travel of the arm is limited by switches (M) and the interreflections are reduced to a minimum by the special shields (K) and (L).

The accuracy of the reflectometer is of an order equal to other methods in determining the emission from surfaces. Fig. 2 shows the comparative data for three methods of measuring a smoked magnesium oxide disc, 12 inches in diameter. The reflectometer curve and the curve determined with considerable accuracy on a bar photometer are in very close agreement while that of the brightness meter, a practical rather than a precision device, would be considered acceptable.

With the automatic recording reflectometer it is possible to take large quantities of curves in a relatively short time. This mass of data can be assembled in various groupings for study. Since the study is of a three dimensional character the more reasonable assumption is that a three dimensional plot would be more effective in presenting the data. Fig. 3 shows the plotting of the "Brightness Coefficient" for one position of the light source within twenty degrees of the grazing angle of the surface. It would require a number of these plots to describe the light reflection characteristics of the pavement as several positions of the source would have to be considered.

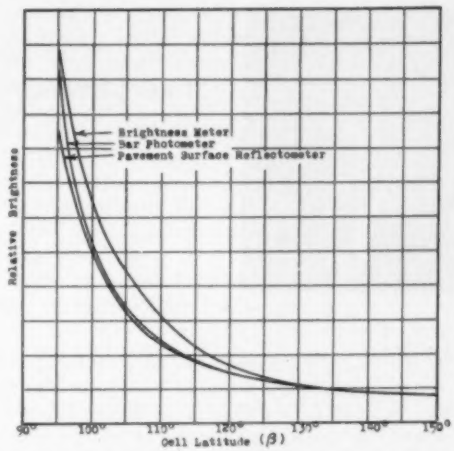


Figure 2. Comparison of results obtained when measuring a magnesium oxide disc by three methods. The source is six degrees above the grazing angle.

The brightness coefficient as described by J. Bergmans is the ratio of the apparent brightness, in footlamberts, to the average illumination, in footcandles. The sample disc is considered a surface source in calculating the "apparent brightness" from the ordinates of the recorder curves.

(Abstract of I.E.S. 1951 Conference Paper No. 15)

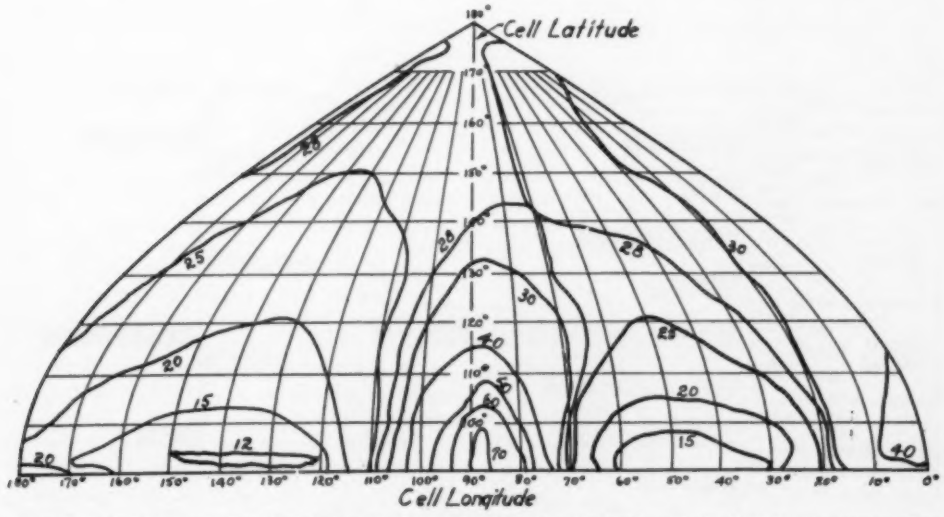


Figure 3. Iso-brightness coefficient plot of a wire-broom finished concrete sample with the light twenty degrees above the grazing angle. Coefficient values in percentage.

Street Lighting—Traffic Accidents—Crime

T. J. Seburn

THE TRAFFIC Engineering Division was given the responsibility for street lighting in Kansas City, Missouri in December 1944. During the early part of 1945, plans were formulated for a complete modernization of the City's street lighting system including all major arteries, residential, and secondary streets. Illumination values were scheduled to meet the modern needs as recommended by the Illuminating Engineering Society. The plans and priority for relighting major traffic routes were based upon traffic and accident data maintained in the Traffic Engineering files while the priority for lighting residential areas was based upon night crime experience.

Orders were placed for equipment at the earliest date they were acceptable by the manufacturers following the conclusion of World War II, and work was started on the installation of the new equipment early in 1946. This work has progressed steadily since that time and by the end of 1950, it was possible to make analysis of the accident experience along almost 100 miles of routes that had been relighted for a sufficient time to study at least one full year of "after" records.

The analysis was made on a recapitulation of over 8,600 traffic accidents reported before and after the lighting improvements were made, and show the following results:

Night-to-Day Ratio.

Type of Accident	Before	After
Property Damage	.59 to 1	.53 to 1
Injury	1.19 to 1	.82 to 1
Fatality	1.75 to 1	1.00 to 1

It will be noted from the above that the greatest improvement is found in the more serious types of accidents.

The accompanying chart shows a graphic presentation of some of the results of the study where accident data were related to the miles of street and

Author: Traffic Engineer, City of Kansas City, Missouri.

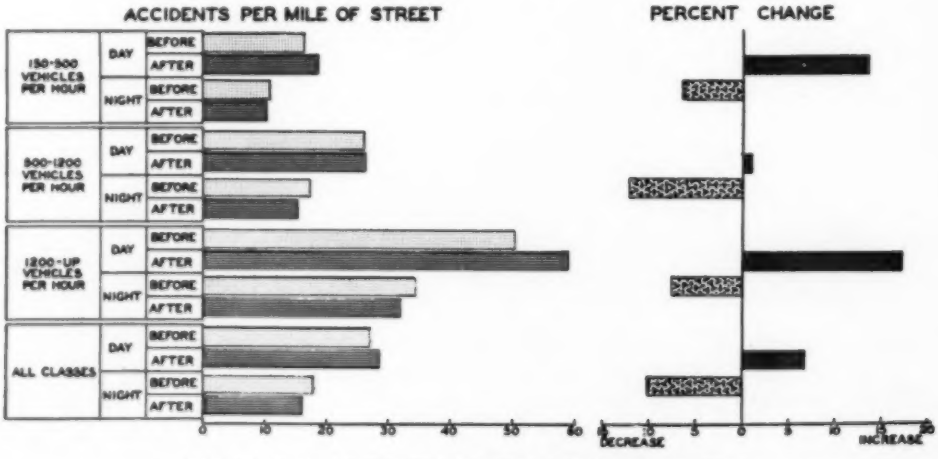


Figure 1. Accident comparison before and after lighting improvement.

further subdivided in volume classifications as set up in the Recommended Practice. Of significance is the bar chart on the right side of this figure showing increases in all classes in daytime and decreases at night.

Similar studies were made in residential areas using records of criminal incidents such as molestation, crimes versus nature, homicide, and auto theft. In this study comparison is drawn with a companion area of similar size that had not been relighted. The results were as follows:

Night-to-Day Ratio of Crime.

	Before	After
Relighted Area	5.9 to 1	3.1 to 1
Unrelighted Area	3.2 to 1	3.8 to 1

Street lighting in Kansas City is provided by the Kansas City Power and Light Company and our annual contract rate to the Company includes fixed charges as well as maintenance, operation, and power. The annual cost of the lighting improvements will increase approximately $70,000.00 for a comparable area of the City. According to figures from the National Safety Council, our lighting improvements have already accounted for a saving of $455,000.00 per year in reduced night accidents alone.

This has been made possible by the use of modern equipment which has cut the annual cost of light delivered to the streets and sidewalks from $47.50 per thousand effective lumens to $12.80 per thousand effective lumens.

(Abstract of I.E.S. 1951 Conference Paper No. 34)

Brightness Patterns On Pavements with Elongated Light Sources

L. J. Schrenk

THE Public Lighting Commission has been experimenting for several years with several types of elongated light sources for street lighting in an attempt to improve visibility at night for the automobilist and pedestrian alike. It is believed that if an elongated light source of low brightness as compared with the point source luminaire could be placed transversely across the street, visibility would be materially improved during all conditions of pavement from dry to fully inundated. These conditions were approached by using several types of fluorescent installations.

The first installation was made in 1945 and operated for two years thereafter. This was a multiple circuit for fluorescent street lighting units placed along the curb, with the fluorescent tubes mounted vertically at an angle of approximately 45 degrees with the pole, thus directing the light to the center of the street. This installation proved very unsatisfactory during the cold weather operation in spite of the fact that the tubes were enclosed in a protective tubing. The breakage was extremely high and the installation was abandoned as it proved too expensive.

The second installation was an enclosed luminaire consisting of three 8-foot T-12 fluorescent lamps placed one above the other and connected in a series circuit through a special transformer. The luminaire was such that it gave no transverse or vertical light control. They were placed on 16-foot brackets with the nearest end of the luminaire eight feet from the curb.

The third installation was connected in practically the same manner as installation #2, being a series circuit. The fluorescent luminaires are mounted in pairs on a ten-foot bracket with the nearest end of the tube placed two feet from the curb. Four 8-foot T-12 lamps are used, two in each luminaire with the luminaires placed at a 30-degree angle with each other. The vertex of the angle is farthest from the curb. These luminaires contain Alzak reflectors, giving both transverse and vertical light control with asymmetric distribution.

Author: General Superintendent, Public Lighting Commission, City of Detroit, Mich.

The study is based on observations and photographs of fluorescent and modern filament street lighting installations. On wet pavements, the elongated fluorescent luminaires give reflected brightness patterns on the roadway that are much broader and cover a greater area than those from the more concentrated filament sources, with their relatively small light controlling auxiliaries (reflectors, prismatic glassware, etc.). On dry, worn pavements, where as a rule there is an element of specularity, the fluorescent units compare most favorably also. The design of the fluorescent luminaires with appropriate light control giving asymmetric light distribution, makes it possible to mount them with less overhang. This adds to the pavement brightness near the curb, and makes the overall brightness more uniform. In addition, the fluorescent luminaire is a large source of relatively low brightness, as compared with the typical filament luminaire, and minimizes discomfort glare in the driver's or pedestrian's field of view.

The installation costs of the fluorescent luminaires are considerably higher than the modern filament street lighting; however, due to the greater increase in light output per watt, the cost of the effective lumen per year on the street is slightly less using the fluorescent luminaire with light control.

The twin luminaire fluorescent installation with its asymmetric distribution, long light sources of low brightness, comfortable to the eye is a most promising step forward in providing visibility on both wet and dry pavements, more nearly approaching that under daylight conditions.

(Abstract of I.E.S. 1951 Conference Paper No. 32)

A Small Portable Street Lighting Evaluator

G. A. Horton

IN DETERMINING the visibility provided by a given street or highway lighting system it is necessary to consider the following factors:

1. The brightness of objects on the pavement.
2. The pavement brightness.
3. The glare or veiling brightness from light sources in the field of view.

In the instrument described, the street lighting installation is observed through a telescope having a very large field and a 1:1 magnification system so that the angular relationships between different objects in the field of view are not altered. In the focal plane of the eyepiece is a transparent disc upon which is a discontinuous neutral wedge consisting of a series of dots of proper size to subtend a slightly greater solid angle than the test object at a 200-foot test distance. A test object of average human size and of average reflection factor for normal winter clothing is used. The disc is rotated until the spot which brings the object to threshold against its background is found. The visibility of the object may then be expressed in terms of wedge density and thus comparisons may be made between different installations. Test stations are usually taken at 30-foot intervals in each traffic lane. The height of the instrument above the street is about five feet or approximately the same as the viewing position of the driver of an automobile. From the measurements, determinations may be made of average and also minimum visibility. The instrument is small, compact, easily portable and an electrical supply is not required. The practical design of this instrument permits the eye to function under almost the same conditions as encountered on streets and highways, that is, pavement brightness, object brightness and glare brightnesses are all taken into account so that the fundamental requirements are largely satisfied.

Results are given of measurements made on different types of street lighting installations.

The design of the instrument is such that its use is not necessarily restricted to street lighting.

(Abstract of I.E.S. 1951 Conference Paper No. 11)

Author: Westinghouse Electric Corp., Cleveland, Ohio.

From the Session on

Residence Lighting

The Photography of Residential Artificial Lighting Effects

E. W. Commery

T. Knowles

THE PHOTOGRAPHY of residential lighting effects presents special problems for at least four reasons: (1) the wide range of brightnesses commonly encountered; (2) the lack of uniformity of brightness patterns within the subject; (3) the relatively low order of the brightnesses of the walls, floors and parts of the furniture, and (4) the need for a reasonably accurate pictorial representation having artistic merit.

Too often dramatic lighting effects are portrayed that never exist in the subject except for the duration of the photographer's lighting setup of spots and floods and the negative exposure. When a subject interior has a lighting design of its own that is worthy of photographic reproduction, much of its effectiveness can be photographed without undue use of contradictory, extraneous photographic lighting.

This paper summarizes the behavior of certain selected photographic materials especially suited to the problem. A system of brightness measurements and specific methods are described. The effectiveness of the system is critically analyzed through a group of photographs that have been made of carefully selected situations. Each of the

Authors: General Electric Co., Lamp Division, Nela Park, Cleveland, Ohio.

Figure 1. The dominant lighting of the table top, the details of the fixture and the overall softness of the general lighting are the objectives of this photograph. The excess brightness of the fixture bowl is reduced with tracing paper liners. The extreme brightness of the center downlight lens is separately controlled by placing a Polaroid filter in the center of the fixture and on the camera lens. Very low fill-in lighting is reflected from large cloth sheets on each side of the camera. The exposure made at f/16 with Super XX film is in three parts—10 seconds for the bowl and downlight of the fixture; 20 seconds for the downlight alone, and five seconds for the fill-in lighting.

situations photographed was chosen to illustrate an overall approach to the problem and to illustrate how differing lighting and furnishing situations were handled. Through the relationships of subject brightness, throughout the interior and the related negative densities, the achievable results are closely predicted. All necessary adjustments of excess or inadequate brightnesses are readily determined from a single basic graph. A second graph permits the estimation of the various reflectances of all parts of the print at the time the subject is being adjusted for the taking of the picture.

Tables of data supply values of subject brightnesses, exposures and resulting negative densities for each of the photographs studied. These data show the dependability of the values incorporated in the graph from which the lighting exposure adjustments for each photograph were determined. The fine qualities of the effects to be photographed are maintained at a high level. Familiarity with good camera techniques and darkroom procedures is assumed since the quality of photograph being sought is at the level of the professional or the skilled technical amateur.

(Abstract of I.E.S. 1951 Conference Paper No. 4)

A Basis for Predicting General Room Illumination in the Home

Priscilla Presbrey

Edith L. Buchholtz

OTHER factors than efficiency and general illumination levels commonly govern the lighting of a home. However, it is often advantageous to be able to predict the approximate footcandles of general lighting that will be provided by a given luminaire in a given room in the home. Heretofore, very little of the necessary information for such calculations has been available. The present paper supplies coefficients of utilization for many of the most common types of residential general lighting luminaires, thus making possible the use of the standard lumen method of calculating average illumination throughout a room. The fixtures selected include suitable equipment for each type of room in the home. For the most part the luminaires are of good lighting characteristics and acceptable styling, although a few less desirable units are included by virtue of their present widespread use.

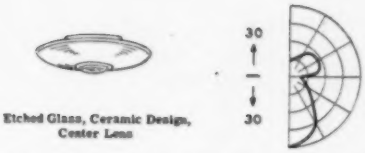
The body of the paper consists of coefficient of utilization tables for forty residential fixtures, together with candlepower distribution curves and efficiencies. The coefficients of utilization were calculated by means of the conventional Harrison and Anderson method from photometric measurements obtained in the laboratory or otherwise available. The data represent typical luminaires of the kinds chosen, rather than specific luminaires. As with calculations for commercial or industrial luminaires, the choice of coefficients to be used for a given fixture should be made on the basis of distribution of light and efficiency, not by appearance alone.

In view of the current decorator trend toward dark walls and ceilings, it seemed desirable to include coefficients for ceilings and walls of lower reflectances than are commonly given for commercial and industrial equipment. Columns for 30 per cent ceiling and 50 per cent wall, and for 10 per cent ceiling with 50, 30 and 10 per cent wall were therefore added to the usual table. No specific recommendations for maintenance factors are given; allowance for depreciation should be estimated on the basis of existing conditions.

The room index table commonly used for commercial and industrial installations also needed some modification for application to residential interiors. The usual table has been altered by adding indexes for lower ceilings and some smaller rooms, and by omitting rooms of dimensions not applicable in the home.

Because of the variable colors and patterns in

Authors: Commercial Engineering Dept. and Residential Lighting Dept., Westinghouse Electric Corp., Lamp Division, Bloomfield, N. J.



A. Luminaire and distribution curve for Table A below.

B. Luminaire and distribution curve for Table B below.

Light Sources	Reflectances: Ceiling	75%			50%			30%			10%		
	Walls	50%	30%	10%	50%	30%	10%	50%	30%	10%	50%	30%	10%
	Room Index	Coefficients of Utilization											
A	J	.19	.16	.15	.17	.15	.14	.15	.14	.12	.14	.13	.12
	I	.23	.20	.19	.21	.19	.17	.19	.17	.16	.17	.15	.14
	H	.25	.23	.21	.23	.21	.20	.21	.19	.18	.18	.17	.16
	G	.28	.26	.24	.24	.23	.21	.22	.21	.19	.20	.18	.18
4 40-W A-19 and	F	.30	.28	.25	.27	.25	.23	.24	.22	.21	.21	.20	.19
1 75-W A-19,	E	.33	.31	.29	.30	.27	.26	.26	.24	.23	.23	.21	.20
All Horizontal	D	.36	.33	.31	.32	.30	.28	.28	.26	.25	.24	.23	.22
	C	.38	.35	.32	.33	.31	.29	.29	.27	.26	.25	.24	.23
	B	.40	.37	.35	.35	.33	.32	.30	.29	.28	.26	.25	.24
	A	.41	.39	.37	.37	.34	.33	.31	.30	.29	.27	.26	.25
B	J	.26	.22	.20	.22	.20	.18	.20	.18	.16	.17	.16	.14
	I	.31	.27	.25	.28	.25	.23	.24	.22	.20	.21	.19	.18
	H	.35	.31	.29	.31	.28	.26	.27	.25	.23	.22	.21	.20
	G	.39	.35	.32	.34	.31	.29	.29	.27	.25	.25	.23	.22
	F	.42	.38	.35	.36	.33	.31	.31	.29	.27	.26	.25	.24
4 Lamps, F	E	.45	.42	.39	.40	.37	.34	.34	.31	.30	.28	.27	.26
	D	.49	.45	.42	.43	.40	.37	.36	.34	.33	.30	.29	.28
	C	.52	.48	.45	.44	.42	.39	.37	.35	.34	.31	.30	.29
	B	.55	.51	.49	.47	.44	.43	.40	.37	.36	.32	.31	.30
	A	.57	.54	.51	.49	.46	.44	.41	.39	.37	.33	.32	.31

One incandescent and one fluorescent luminaire are shown with their tables as samples giving coefficients of utilization. In the paper forty units are given.

wall treatments, fabrics, and floor coverings, and because of the small rooms in which the effect of furnishings, wall openings, and irregularities is relatively great, the lumen method can probably never be applied as accurately in the home as in a schoolroom or a large office. However, the information presented in this paper may prove a useful guide to the illuminating engineer or lighting specialist confronted with the problem of determining the fixture capacity required for specified general lighting levels in various residential interiors.

(Abstract of I.E.S. 1951 Conference Paper No. 25)

Current Goals—Hibben *(Continued from page 435)*

18 leisure years (most of which is under artificial lighting) or to sleep peacefully his 19 years!

Almost from birth Mr. Average Man finds his physical "seeing system" depreciating at a rate of approximately three per cent per annum. Without "eye crutches" or reading glasses (spectacles) he would be half blind after reaching maturity and even with the best known optical aids and regardless of his general social classification or environment, he finds that his *ability to see decreases much faster than almost any other bodily function!*

Today he knows of very little that can improve the seeing processes in the cortex of the brain, nor of the optic nerve nor in the retina or other parts of the eyeball. Thus Mr. Average Man turns to better lighting as almost his only hope for the easement of today's mounting strains on vision. He may well be alarmed when he contemplates what may happen to succeeding generations should good lighting not come to their aid before natural evolution can reverse this tendency towards loss of visual acuity or indeed essential blindness.

It is to this man that we must dedicate the services of the Illuminating Engineering Society. No individual alone, least of all your President, can do much more than to encourage the continuous fine feeling of coordination and cooperation within the ranks of the Lighting Fraternity. This is *your* Society and its officers will be your willing servants.

Proposed Designs for Lighting Education In Home Economics Colleges

Kaye A. Leighton

THE EXPANSION of Home Economics Education to include Home Furnishings, Housing and Equipment has brought about an intensified interest in the teaching of lighting education. The present need within this field of education is for demonstration materials and not too costly demonstration centers. That these two factors could be combined satisfactorily is the purpose of this paper.

Extensive studies of five rooms typical of a Home Management House have been made. These five rooms are herein illustrated to show how the method of "Visual Planning" will bring about a natural co-ordination of the individual with all of the factors which compose an indoor environment.

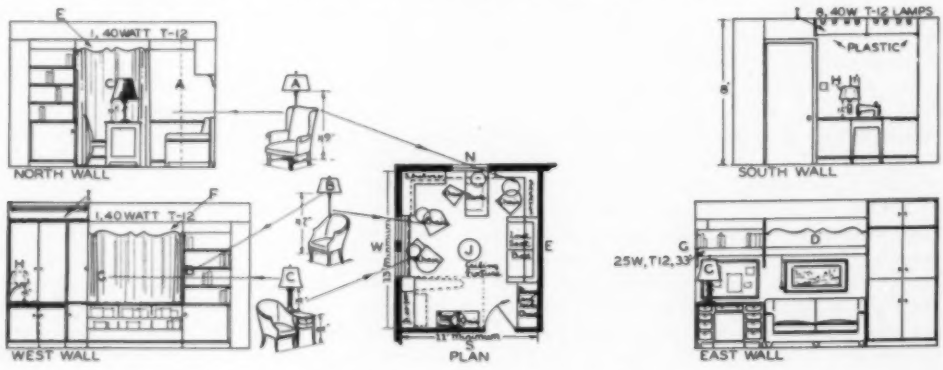
The developing of "Visual Planning" as a consistent part of Home Furnishings, Housing and Equipment teaching is a new concept offered for the consideration of those interested in working with educators in the development of applied lighting practices.

(Abstract of I.E.S. 1951 Conference Paper No. 18)

Author: General Electric Co., Lamp Division, Nela Park, Cleveland, Ohio.

Today's living needs bring about a changed concept of the function of enclosed space. Any single room area must offer the possibility of multi-purpose use in order to justify its existence. The room illustrated provides for six activities — Reading, Studying, Sewing. Small Group Entertaining, Committee Meetings and Overnight Guest. These activities involve twelve different visual conditions which include casual and concentrated reading for short and prolonged periods; desk study, both reading and writing; magazine and book selection; machine and hand sewing; fine detailed handicraft; relaxed conversation and card playing; the taking of committee notes and reading of notices on bulletin board; reading—reclining, and general maintenance. By the Visual Planning method of providing for required visual conditions of both a localized and general nature enclosed space is organized to render greater usefulness.

VISUAL PLANNING - UPSTAIRS STUDY AND COMMITTEE ROOM - AREA 143" MULTI-PURPOSE ROOM



Jan Reynolds

The Control Aspects Of Residence Lighting

THIRTY or thirty-five years ago, few convenience outlets or plug receptacles were installed when a house was "wired" for electricity. Consequently, the consumer purchased double or triple plugs, screwed them into the light bulb socket, plugged in appliances or a couple of extension cords and then proceeded to work "efficiently." Thus, she did have electricity, but she was working for it almost as much as it was working for her.

The situation has certainly improved today, but the most adequate wiring and lighting can lose a large part of its value and effectiveness unless the control is carefully planned. Although the average first-class home built a few years ago was provided with ample wiring capacity to handle lighting and appliances in use at that time — plus a reasonable margin for increased load — the past five or six years has seen television (500 watts), electric blankets at 200 watts each, deep freezers (350 watts), dishwashers (600 watts) and even clothes dryers (4500) widely used. Even lighting has increased about 700 watts in these middle class homes. This represents a total of 6859 watts not anticipated five or six years ago, so we must prepare for additional load as well as the proper control of this domestic servant—electricity. It can be expected, therefore, that in 1962 a further additional load of 7000 watts of electricity will be used in the average home.

The purpose of this paper is to emphasize the fact that we as a lighting group cannot expect the widest appreciation and acceptance of the use of light unless we complete our job by also emphasizing the proper means of control.

For example, the most effective use of lighting often requires control from two or more locations. With only one control, the convenience and safety value of the illumination is reduced 50 per cent. A three-way switch should be located on the lock side of the door in the hallway, so the light may be readily turned on upon entering from the outside. A wall switch to operate two or three convenience outlets is necessary when entering the living room, when the center ceiling unit has been eliminated. The distribution panel with either fuses or circuit breakers might be placed in an accessible location, perhaps in the kitchen instead of in the basement. Also, if a convenience outlet or switch is located within easy reach of a sink the chance of electric shock is greatly increased since it becomes possible to have one wet hand on the faucet or in dishwater and the other one on the switch.

Thus, it is not enough to merely recommend a practice of locating and installing residential lighting equipment without including with such data, the information necessary for its most advantageous and flexible use.

(Abstract of I.E.S. 1951 Conference Paper No. 29)

Author: Home Lighting Consultant, Sylvania Electric Products Inc., New York, N. Y.

Errata

The caption for Figure 1 on page 423, August 1951 ILLUMINATING ENGINEERING, for the article relating to Gasoline Service Stations, should read: "Horizontal service-station pump-island lighting device employs hot-cathode slimline fluorescent lamps, using T12 4500-degree white 430 milliamp tube." Reference to this figure on page 424, column 2, second line, should also read "hot-cathode slimline fluorescent."

From the Session on

Government

Light, Color and Environment in Government Offices

L. M. Endres

THE PURPOSE of this paper is to consider certain phases of the relationship between light, color, and environment in the newer Government offices. We all realize that there is a relationship between light and color as elements of environment, but in the past many of us may have failed to appreciate the full extent of that relationship and the dependence of one element upon the other in creating satisfactory conditions. The artist is keenly aware of the effect that changing light has upon his colors. He can work at his best only when the light is "right." The decorator also realizes that light sources will affect the appearance of colors in his work.

However, does the decorator realize that the colors he uses greatly affect the lighting provided by the illuminating engineer? The engineer has found that he must supply more sources of light in a dark colored room than in a light colored room to obtain a given level of illumination at the working plane. Does he know, however, that the addition of more light sources does not necessarily produce a good lighting job?

We have found that the levels of illumination which are required today are much higher than those used previously. The increase has resulted from the constant research in lighting which demonstrated that better and more work could be done under higher levels of illumination. However, the providing of these high levels of illumination has changed the thinking of designers in the preparation of layouts for offices. The art of lighting has progressed from a design where fixtures were installed in a haphazard manner to a design where each element of the lighting installation is carefully planned. Where high levels of illumination are used the lighting fixtures must be carefully designed to avoid transmitting excessive light into the workers' eyes.

In order to reduce the overall brightness it was believed that the fixture should have no part which is brighter than three times the brightness of the ceiling.

Where good seeing conditions are important we have found that the semi-direct or luminous indirect fixtures give the best brightness ratio between the fixture and the ceiling.

The ceilings should be painted a flat white, reflectance not less than 75 per cent, with a 60° specular gloss reflectance of 0-8 per cent.

The walls should be painted in light colors having a reflectance of 50 to 60 per cent or a Munsell value of between 7 and 8. The 60° specular gloss reflectance of the finish should be between 15 and 30 per cent.

The following colors have been developed by intensive experimentation and will provide a good working environment:

Green	5GY-8/2
Buff	7.5YR-8/4
Gray	10YR-7.5/1
Blue Green	5BG-8/1.5

The doors, baseboards, and dado (if required) should be painted in the same Munsell hues and

Author: Chief, Electrical Section, General Services Administration, Washington, D. C.

chromas as the walls with a value between one and two points lower.

The finish of the paint will give better washability if the 60° specular gloss reflectance is 20 to 40 per cent.

The floors should be covered with a material having a reflectance of 20 to 30 per cent. The color of this covering can be either similar or contrasting to the wall color.

Tests have indicated that the efficiency of the lighting in an office increased from 9 to 25 per cent by painting, cleaning of fixtures, replacement of lamps and replacement of floor covering.

Now that we have increased the level of illumination we must be sure that the furniture is light colored to reduce brightness ratios in the workers' field of view. Desks should have a working surface which has a reflectance of at least 35 per cent. Thus the employee who is working on paper having a reflectance of 60 to 70 per cent will not have any brightness ratio greater than 3 to 1 in his line of vision.

In our report on a test in a card punch operation in the Internal Revenue Building published in a pamphlet entitled "The Influence of Lighting, Eyesight, and Environment Upon Work Production," it was found that the increase in work production was 5½ per cent.

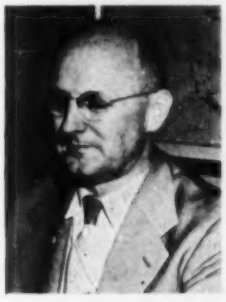
Another test was run in a card punch operation in the Census Bureau.

This test showed a 3½ per cent increase in work production!

These tests indicate that the environment of the worker is very important in providing an increase in work production. We have found that the brightness ratios are too high under all types of lighting unless color conditioning is provided. We believe that these tests indicate that high levels of illumination should not be used without providing high reflectance on the working surfaces to reduce brightness ratios.

(Abstract of I.E.S. 1951 Conference Paper No. 44)

Public Building Service in the Lighting Field



Thomas F. Coghlan

I REALIZE that there are many in the various branches of the lighting industry who don't have a clear picture of our functions and our responsibilities. Many may also wonder why we have assumed such a definite position in designing as well as purchasing lighting equipment. I believe, however, that with an explanation of our overall operation you will agree that all consumers, whether a private concern or a Government agency, who must purchase lighting equipment in the quantities that are used by the Public Buildings Service, should carefully study and plan their own needs and, if necessary, better to meet their requirements, they should develop their own designs based on their particular requirements if commercially available equipment does not meet all phases of their operation.

I want to emphasize the fact that we have a very logical place in this business of illuminating engineering. Our planning is based on years of experience in designing and operating Federal buildings and a sincere effort to obtain lighting equipment that is most suitable for the Government's needs. We have solicited suggestions and criticisms from employees throughout our Regional Offices as well as from the operating employees in the individual buildings.

It is our aim to see that the illumination of Federal buildings will be as adequate and modern

Author: Electrical Section, Public Buildings Service, General Services Administration.

as it is practical to make it. We intend to see that the illumination in our buildings fully complies with the requirement that Federal buildings be functional in all respects.

The days of installing lighting fixtures just to be looked at as architectural features are gone. We propose to eliminate the monstrous lighting standards and lanterns that have adorned so many public buildings.

Exterior lighting equipment will be built into soffits or walls and be as inconspicuous as possible, fitting into the architectural features.

Generally, our office areas and drafting rooms will be illuminated by luminous indirect fluorescent lighting equipment, except, of course, in cases where of necessity the finishes, ceiling height, or some other condition may prevent us from providing the ideal and require a compromise.

The decision to standardize on the luminous indirect system of lighting was based on the fact that it has proven to be more satisfactory because of its ability to produce adequate intensities with a minimum of both direct and reflected glare. With proper spacing of fixtures and suitable suspension from the ceiling, brightness ratios far better than those recommended by the Illuminating Engineering Society are obtainable.

An interesting and unusual characteristic appears to be inherent in this luminous indirect type of lighting system—as dust accumulates on the lighting equipment and on the ceiling, the comparative brightness ratios tend to draw closer together and possibly improve, even though the quantity of light naturally is reduced by depreciation of lamps and the accumulation of dirt.

I am not recommending that dirt be encouraged to accumulate but I do want to point out that the very important matter of comparative brightness changes only slightly during the natural depreciation period.

Our problems include many types of work other than purely office tasks. We have found that the louvered bottom, open top type of fluorescent lighting fixture, designed within certain requirements is quite satisfactory for moving tasks such as those performed in post office workrooms.

We are convinced that we should design our own line of standard fixtures because by that practice only can we obtain real competitive bids, with all bidders and manufacturers placed on the same basis. We can also obtain fixtures superior from our standpoint to the usual commercially produced fixtures.

One advantage of standardization is being able to remodel and extend our existing lighting systems, joining new fixtures directly to existing equipment or buying end plates or other parts by real competitive bids. We do not have to frame up a specification based on trying to get the same manufacturer who made the original fixtures, and perhaps hoping that he hasn't discontinued or changed his line so they won't match the originals.

Another advantage lies in the importance of knowing all the details and necessary dimensions of the lighting equipment when planning new or remodeling old buildings. We can plan with a considerable degree of accuracy and not have to wonder which one of many dimensionally and otherwise different commercially available stock fixtures may be installed on the job.

In developing our designs we have kept several points in mind; they must be substantial, maintenance operations must be simple, practical and as convenient as possible, dust collecting contours and decorations must be eliminated so far as possible, and they must de designed so that accessories that are subject to possible replacements may be serviced with the least possible dismantling of the remainder of the equipment.

All of this is of utmost importance to us in the Design and Construction Division because after the equipment is installed our Buildings Management Division takes over and operates and maintains it. So, you see, we have to live with what we design.

Although the progress of our program has been somewhat disrupted since World War II, we have sufficient quantities of our standard lighting fixtures in use to convince us that our policy is right and definitely in the Government's interest.

One large project that has recently attracted attention is the new General Accounting Office Building here in Washington, D. C. Although actually commenced before World War II, construction was abandoned during the war period. The delay will prove to be fortunate for the eyes of the employees assigned to that building because it has resulted in the planning of a more adequate lighting system than would have been done in the early 40's. The office areas are provided with luminous indirect fluorescent lighting which, with reasonable maintenance, will deliver intensities better than 30 footcandles with brightness ratios of less than 2 to 1 between the luminous body of fixture and the brightest and darkest ceiling areas above and between the luminaires.

This building, as well as many other Federal buildings, should offer sufficient evidence as to why we are in every phase of this field of illuminating engineering except the actual manufacture and installation of the equipment.

(Abstract of I.E.S. 1951 Conference Paper No. 45)

Built-In Lighting

LIGHTING OBJECTIVE: To provide local lighting at the telephone area and additional general room illumination.

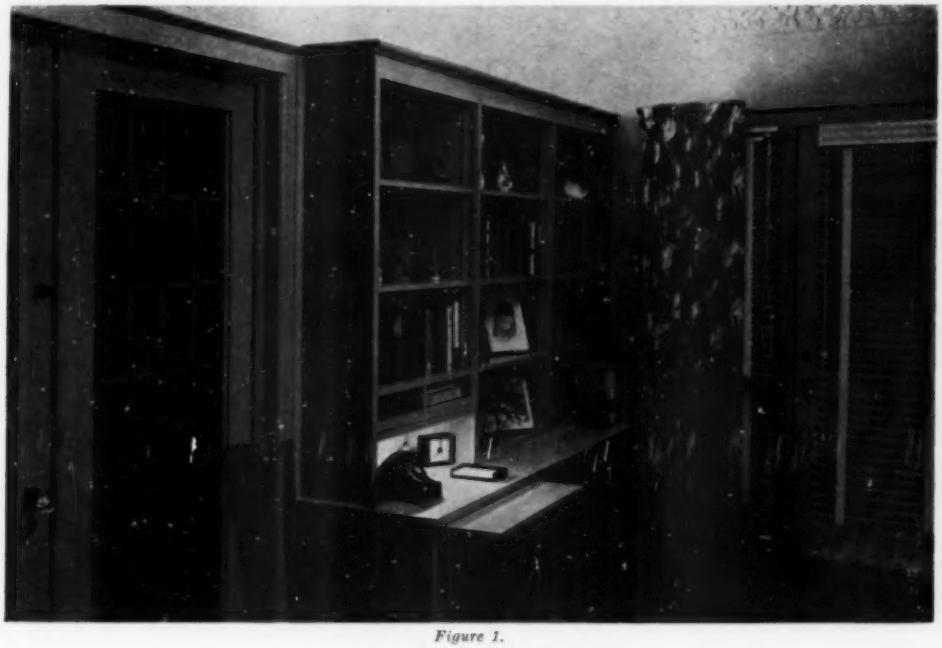


Figure 1.

Installation at Detroit Michigan.

General Information: The room is 14½′ x 10′ with an eight-foot ceiling. The walls, woodwork and built-in bookcase are green (61% reflection factor) and the ceiling is white (85% reflection factor). The carpeting is gray green (55% reflection factor).

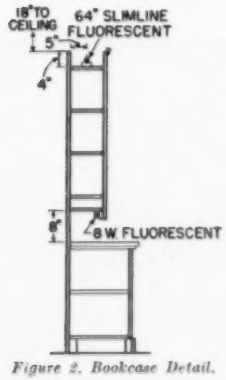


Figure 2. Bookcase Detail.

Installation: A two-inch (½-inch thick) board added to the small telephone recess conceals an 8-watt fluorescent lamp. The ballast is concealed in the cupboard below and a switch mounted next to the lamp controls the unit. To supplement the ceiling fixture (Lightolier Co. #6283 with three 40-watt filament lamps), one 64-inch slimline fluorescent tube (Wiremold #21564) is placed in the four-inch deep recess at the top of the bookcase. This is mounted five inches from the wall. The ballast is located in the basement and the unit is controlled by a wall switch located to the side of the bookcase. Resultant illumination and brightness measurements with bookcase lighting and ceiling luminaire are indicated below:

Brightness		Illumination	
Phone Dial	3.0 to 5.0 Ft-L	Room Average	9 ft-c
Pull-out Shelf	2.0 Ft-L	Phone Dial	25 ft-c
Bookcase Ledge	3.5 Ft-L	Pull-out Shelf	9 ft-c
Bookcase Front	1.0 Ft L		

Lighting data submitted by Mary Taepke, The Detroit Edison Company, Detroit, Michigan, as an illustration of good lighting practice and to aid in the design of similar installations.

Published by the Committee on Publications of the Illuminating Engineering Society
1860 Broadway, New York 23, N. Y.

A.I.A. File No. 31/14

Current Lighting Practice For Television Production

Prepared by Subcommittee on Lighting for Production of Television Programs of the Committee on Television Lighting of the Illuminating Engineering Society*

PREFACE

This report summarizes existing current practice in lighting for the production of television programs. Enormous strides have been made in the past two years in camera tubes, lighting units, wiring and control systems, and also with the techniques involved. The I.E.S. Television Lighting Committee has been concerned primarily with what lies in front of the camera and has made no endeavor to report on either the complicated camera control or the artistic technique in using light to create special effects.

This report was used by the Television Committee of the U. S. National Committee of the International Commission on Illumination at the 1951 Sessions in Stockholm, Sweden to describe the status of television lighting in the United States.

SUBCOMMITTEE ON LIGHTING FOR PRODUCTION OF TELEVISION PROGRAMS

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R. S. O'Brien	F. E. Carlson

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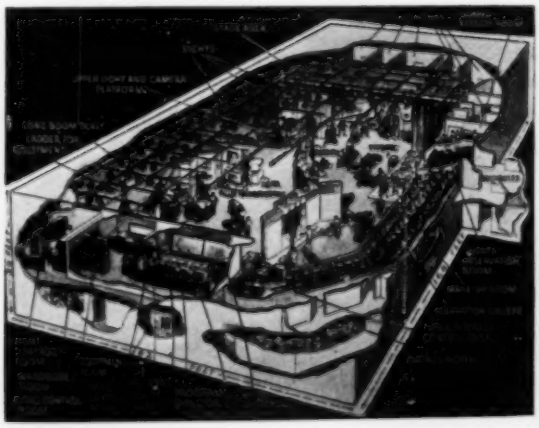
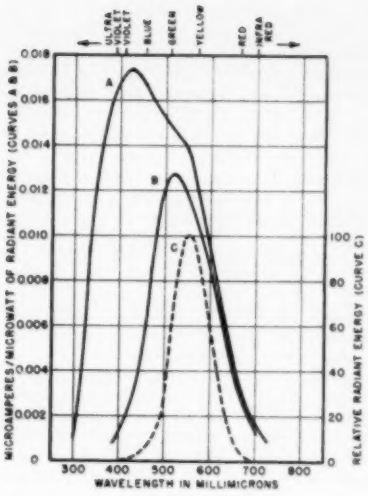
*Approved by the Council of the Illuminating Engineering Society, December 1950.

Figure 1. Typical large television studio: (left) photo showing overhead lighting equipment; (right) artist's view.





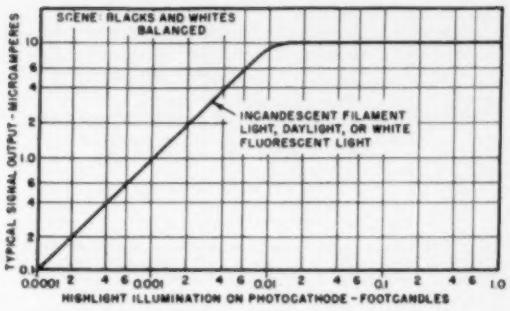

SCENE: BLACKS AND WHITES BALANCED
INCANDESCENT FILAMENT LIGHT, DAYLIGHT, OR WHITE FLUORESCENT LIGHT
TYPICAL SIGNAL OUTPUT - MICROAMPERES
HIGHLIGHT ILLUMINATION ON PHOTOCATHODE - FOOTCANDLES

Figure 2. (left) Spectral sensitivity characteristic of type 5820 image orthicon: curve A, without filter; curve B, with Wrattan #6 filter; curve C, spectral sensitivity of average human eye.

Figure 3. Typical signal output of type 5820 image orthicon.

Television Cameras

The latest and most commonly used television camera pickup tubes are the #5820 and 5826 image orthicons. For film transmission the #1850A iconoscope is used most frequently. Figures 2 and 3 show the spectral sensitivity of the 5820.

The choice of lenses as to size and focal length and the mode of operation with respect to apertures and angles of view are dictated by the needs of a given scene or subject being televised, and are governed by the same principles commonly applied to all photographic work scaled to the size of the mosaic of the pickup tube used. Diagonal of photo cathode area used for 4:3 aspect image is 1.6 inches. Focal lengths and calculated widths of scene relative to the normal lens-to-scene distance for lenses commonly used in studio work are shown in Figure 4. The focal lengths of the three lenses per camera normally used are 50 mm, 90 mm, and 135 mm. Lens stops are adjusted to obtain proper exposure in present practice — normally being set at f8 to f16 — this range resulting from tube-to-tube sensitivity variations and from illumination level variations.

The practical brightness contrast range for operational use is considered to be 30 or 40:1, although

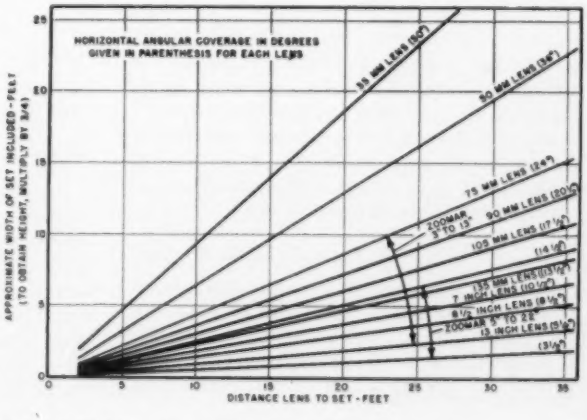
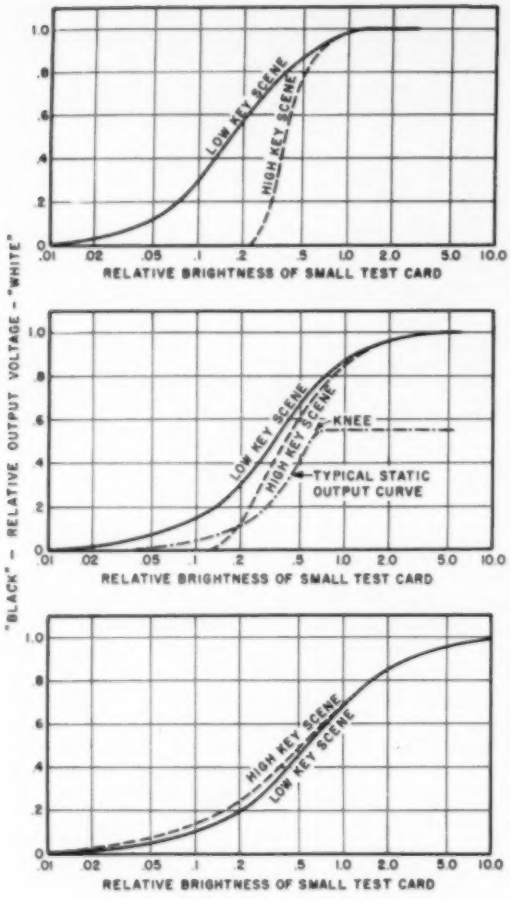

HORIZONTAL ANGULAR COVERAGE IN DEGREES GIVEN IN PARENTHESIS FOR EACH LENS
35 MM LENS (54°)
50 MM LENS (36°)
75 MM LENS (24°)
ZOOMAR 5° TO 13°
90 MM LENS (20°)
102 MM LENS (17½°)
(14½°)
135 MM LENS (11½°)
7 INCH LENS (10½°)
8½ INCH LENS (8½°)
ZOOMAR 5° TO 22°
13 INCH LENS (5½°)
(3½°)
APPROXIMATE WIDTH OF SET INCLUDED - FEET (TO OBTAIN HEIGHT, MULTIPLY BY 3/4)
DISTANCE LENS TO SET - FEET

Figure 4. Lens coverage widths for lenses used with typical image orthicon cameras.


"BLACK" — RELATIVE OUTPUT VOLTAGE — "WHITE"
LOW KEY SCENE
HIGH KEY SCENE
RELATIVE BRIGHTNESS OF SMALL TEST CARD
KNEE
TYPICAL STATIC OUTPUT CURVE
RELATIVE BRIGHTNESS OF SMALL TEST CARD
RELATIVE BRIGHTNESS OF SMALL TEST CARD

A — Target-Screen Potential, 1 volt

The very bad suppression of low and intermediate tones with a light (high key) average scene results from widespread re-distribution of secondary electrons knocked off from target and target screen.

In an actual scene, a pace which registered a relative brightness of 0.3 would change from white to black if the performer walked from a position in front of a low-key background to a second position in front of a light background.

B — Target-Screen Potential, 2 volts

Compared to A, less severe suppression occurs. However, note the limited range of scene brightness accommodated (.15 to 3.0 or 20:1) with a high key scene. With this adjustment, the most noticeable changes occur in the "blacks."

To indicate the difference between the dynamic transfer characteristics and the static output curves shown in tube handbooks, a typical static curve is shown. The difference comes about from electron re-distribution where, as is nearly always the case, major portions of the scene exceed the brightness corresponding to the so-called knee of the static curve.

C — Target-Screen Potential, 3 volts

Here, the secondary electrons are prevented from landing and filling in "black" areas by the high screen to target potential. They are collected by the screen. The curve with a high key background actually raises low and medium tone values, due to the secondary effects of flare and scatter light.

Note that as the target voltage is increased a longer and less changeable gray-scale or dynamic transfer is obtained. The limit is set by the signal to noise ratio. Greater target voltage requires higher beam current to discharge high lights, increasing the picture noise level. In practice, a target voltage somewhere between A and B will be found optimum. The possibilities of adusting target voltage to obtain gray-scale balance among camera tubes are obvious.

Figure 5. Dynamic transfer characteristics for image orthicon showing effects of average scene brightness and target voltage adjustment with video gain and blanking readjusted in each case for constant signal amplitude.

in some cases it may be higher. See Figure 5. Filters[1] are used where fluorescent sources of light are employed. These filters cut off sharply at 450 millimicrons, eliminating strong mercury vapor radiation at shorter wavelengths. The filters may be retained with incandescent sources and their use allows sources to be intermixed freely.

Illumination Levels Required

The following ranges of illumination levels for general lighting are typical of general practice:

Tube 5820	30 to 100 footcandles
Tube 5826	100 to 200 footcandles

[1]Wratten 23 or 26 equivalent.

These levels are subject to wide variation depending on the reflectances of the subject material being televised.

Measurement of Illumination

The amount of incident light is measured with a photocell meter calibrated for incandescent sources (approximately 2900K) holding the photosensitive element at the scene perpendicular to the axis of the camera lens at approximately lens height and facing the lens. The present trend, for more accurate readings, is toward the use of a color-corrected cell similar in spectral response to that of the pickup tube (viz., approaching the nor-

mal eye sensitivity curve) and with a cosine-corrected shield for broad angle reception. Practice has shown this method to be a good index of the lighting of the scene. Reflected light measurements have been proposed and experimented with but not widely used.

Brightness Ratios

Backlighting,[2] keylighting,[3] and modeling lighting[4] levels generally are maintained at 1½ to 2 times that of the base or general incident illumination.

The maximum brightness range in a scene should not exceed 40:1 and is preferably kept at 30:1 or

Lighting Equipment

Television studio lighting equipment is completely adjustable in direction, capable of being easily moved (therefore light in weight), and has easily controlled beam spreads (units other than floodlights). All lighting units are equipped with yokes, pipe clamps and short cables with connectors.

Base Lighting

The general or base lighting is usually supplied by incandescent floods (scoops), long range scoops, or banks of fluorescent lamps.

Scoops vary in size from 14" to 18" diameter and use from 500- to 2000-watt lamps. They are a combination parabolic and elliptical shape and have diffuse (matte) anodized aluminum reflecting surfaces.

The long range scoop, similar in size, has a combination specular parabolic reflector and diffuse sides. The beamspread is adjustable, providing a beam pattern similar (to the scoop) for the longer throws (20 to 25 feet) now encountered in the larger studios.

Fluorescent units generally consist of a bank of six 4500 or 3500K (or a combination of the two) fluorescent lamps, each with an individual anodized aluminum shallow parabolic reflector. These units are approximately 26 inches wide, 5 inches deep, and either 65 or 43 inches long. Two-lamp lag-lead ballasts are generally installed in a separate box with 10 to 20 feet of cable between the lighting unit and the ballasts. More recently, due to improved ballast and luminaire design and where sufficient luminaires are installed to eliminate constant relocation, the units have self-contained ballasts.

[2]Light originating from behind, used to separate the subject from the background.

[3]The principal illumination falling on the subject from a source which is part of the scene.

[4]Used to enhance the appearance of a subject and for creating artistic effects.

TABLE I.—Incandescent Filament Light Sources Used for Highlighting, Key Lighting, Base Lighting, and Rear Projection.

	Available Lamps	Filament	Hours Life
For Fresnel Spots			
3" lens units	100-watt G16½	CC13	200
	150-watt G16½	2CC8	200
6" lens units	500-watt T20/64	C13	500
	500-watt T20/48	C13	200
	750-watt T20P	C13D	25
8" lens units	1M/G40/P8P	C5	200
	1500/G40/15	C5	200
10" or 12" lens units	1M/G48/8	C13	100
	2M/G48/17	C13	200
14" or 16" lens units	5M/G64/3	C13	75
For Floods			
Baby scoops	500/IF	C9	1000
Scoops	1000 IF	C7A	1000
	1500/IF	C7A	1000
Long range scoops	1000/T24	C13	1000
For Elliptical Units (Base-up burning)	50C/T14/8	C13D	200
	1500/T24/6	C13D	200
	2M/T30/1	C13D	200
	3M/T32/2	C13D	100
For Sunspots	1M/G40/SP/5½	C5	200
	1500/G40/10	C5	200
For Striplights	150R/SP	C11	1000
	150R/FL	C11	1000
	300R/SP	CC2V	1000
	200R/FL	CC2V	1000
	200/IF	C9	1000
	300M/IF	C9	1000

Mercury vapor lamps are no longer used in regularly operating studios although some experimental installations have been made. Arc lamps and ultraviolet (365 millimicrons radiation) are not used in normal television studio lighting practice; however, blacklight is sometimes used for special effects.

Accent Lighting

The equipment used for highlighting, backlighting and keylighting consists primarily of Fresnel lens spotlights and elliptical spots. Fresnel spotlights, the more flexible of the two (also used sometimes for controlled floodlighting), are available in the following sizes:

3" lens	—	for 100-150 watt lamps
6" "	—	" 500-700 " "
8" "	—	" 1000-1500 " "
10 or 12" "	—	" 1000-2000 " "

These are all equipped with specular spherical reflectors and generally have the lens risers painted black to reduce spill light. They have spindle-adjustment focusing feeds.

The elliptical spots provide accurate control of the beam by means of built-in adjustable square and iris shutters. They come in three sizes with a variety of lenses depending on the maximum degree spread required for the particular distance the unit is to project. The smallest is the 500-watt

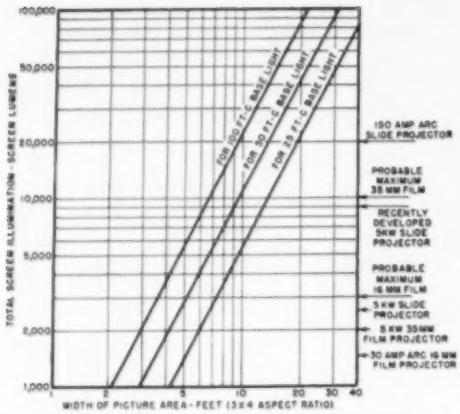


Figure 6. Rear-projection capability of typical projectors; high light brightness 70 footlamberts (equal to reflected high lights), 50 per cent screen transmission, slide or film density 0.3 (transmission 50 per cent).

unit, the next the 1500/2000-watt unit, and the largest takes a 3000-watt lamp. The 2000-watt 12-inch diameter lens and the 3000-watt 12-inch diameter lens units are used primarily as follow spots.

Numerous other types of lighting equipment are used, including such items as the "sun projectors" which are identical to small searchlights, reflector type and reflector-lamp type striplights for background lighting and for use overhead in theaters, portable spotlights and floodlights (identical units as above but mounted on roller caster stands), clip-on reflectors and reflector lamps for highlighting, and other items. See Table I.

Projected Backgrounds

Rear projection is used to simulate background scenery which may take the form of stationary objects as in a slide; moving effects such as clouds, water, etc.; or motion pictures to simulate moving trains, motion from an automobile, etc.

For realism, projected highlights should be between ½ and 1 times live highlights. A projected highlight brightness of 70 footlamberts measured facing the screen from the camera side for normal base-light level of 100 footcandles is desirable. The total beam or screen lumens for various screen widths and for several base-light levels is shown in Figure 6. Distribution should be such that all areas of the screen as measured from the camera side without a slide or film should be within 10 per cent of average brightness. The general dimensions of the screens run from 14″ x 18″, 5′0″ x 7′0″, 8′ x 12′ to 12′ x 18′.

Where slide projectors are used, slides vary from 3¼″ x 4¼″, to 4″ x 5″ with 2100-watt 60-volt, 2000- and 5000-watt standard voltage incandescent filament lamps. The maximum area satisfactorily covered to date has been 9′0″ x 12′0″. The widest angle lenses used have a 6¼″ focal length.

Up to the present time, 16 mm film has been used in background motion picture projectors with 1000-watt incandescent filament lamps for screen sizes up to 5′0″ x 7′0″ and with 30-ampere high intensity arcs for screens up to 9′0″ x 12′0″. Lenses used are 20 mm focal length.

The normal brightness range between foreground and projected background is governed to a large extent by the type of screen material used and generally lies between 3:1 and 5:1.

Control Equipment

Since approximately 95 per cent of the studio lighting is done from overhead, it improves production and has proved to be most economical to provide many overhead outlets and pieces of lighting equipment. The outlets, generally arranged on 2-foot centers across the studio and in rows 6 to 8 feet apart, consist of 3-foot cables with female stage type connectors attached. Each outlet is wired to a switchboard at which it may be individually controlled or if desired grouped with other outlets to the same master control. The switchboards are equipped with numerous 4000-watt autotransformer type dimmers. These enable the lights to be either dimmer controlled or not.

Two types of boards currently used are:

1. *The patch plug type.* This method generally has 3 or 4 female connector outlets per circuit. The outgoing circuits are connected to pigtail cables which are energized by plugging into the female connectors. By this method several outgoing circuits may be grouped together onto the same control, providing flexibility in the grouping of lights.

2. *The selector switch type.* Use of rotary circuit selectors (see Figure 7) eliminates patch cords entirely. For example, an outgoing circuit equipped with a 12-point selector* can be connected to any of the 12 feeder circuits (either dim or non-dim type). It also means that any number of such outgoing circuits can be thus connected to the same feeder circuit, thereby providing great flexibility in the grouping of lights. Each unit has its own automatically acting disconnect switch eliminating any make or break of current on the circuit selector. The disconnect switch can also be used as the individual control switch for that outlet.

*One type termed "rotolector."

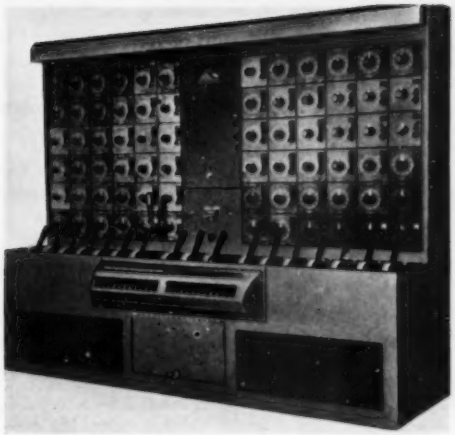


Figure 7. Rotary selector type switchboard.

Luminaire Installation

The method of supporting the lights depends to a great extent on the ceiling height and the intended use of the studio. Where height is low (12 to 16 feet) a permanent pipe grid is usually installed from which the units are hung directly or through available pantographs (see Figure 8) which permit individual vertical setting. In either case, the units are capable of complete rotation and tilting.

In high-ceiling studios and in television theaters, the lighting units are supported either from fixed pipe grids or on conventional pipe battens. In television theater studios a larger amount of front light (either on the balcony front or across the proscenium) is used than in regular stage performances. Vertical pipe standards in the wings are used for fastening side lights. In this type of high-ceiling studio a large number of the lights are equipped with the pantograph hangers.

No brief resume can satisfactorily describe the requirements for the lighting layout in the television theater studio, the workshop-type of studio, or the repetitive-type of program studio. Each type must be analyzed for the architectural properties, the degree of flexibility, and the general program material which may originate in a particular space. Extensive literature exists describing existing studios of all types, and very few are exactly alike. Detailed descriptions must await further development; possibly some degree of standardization may eventually result.

Film Production

Films as used for television transmission are made either in a motion picture studio or filmed directly from a television picture tube, the latter usually during a regular on-air production. A much higher contrast range (100:1) can be tolerated in theater motion picture work than in television where the pickup tube limits this range to 40:1. In addition, in television the contrast is increased throughout the system and (starting at a 20 to 30:1 ratio) the final results, at the receiver end, are comparable in contrast range to theater motion pictures. Minimum scene illumination levels (for television film) are of necessity kept higher to overcome electrical noise.

In normal motion picture practice, scenes can be taken without regard to sequence indicated by the original story and are usually governed by set locations and then edited into the proper order called for by the story. As a result, the lighting set up can be interrupted, reset, and adjusted, to suit the circumstances as often as necessary.

Kinescope recording, usually made during an on-air production (for rebroadcast purposes as well as normal television broadcasting), requires extensive pre-planning of the lighting arrangements, switches, dimming, etc., because of the necessity of continuous action. An exceptionally high degree of mechanical and electrical flexibil-

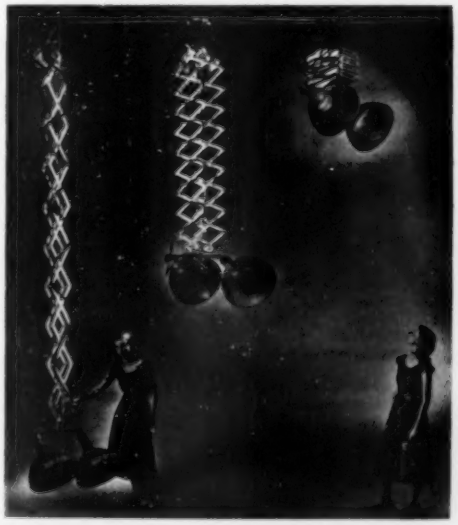


Figure 8. Pantograph devices permit raising or lowering of lighting equipment as well as horizontal and vertical adjustments.

ity is mandatory. Multiple sets are arranged for instantaneous switching. Consequently, the lighting for each scene is preset without mutual interference with adjoining sets. The contrast range, normally 30 to 40:1, is kept to a minimum of 20:1 consistent with the overall effect desired when recordings are being made.

Field Pickups

A large part of field pickups occur during the day and natural daylight is more than adequate. Where artificial illumination is required, incandescent sources of the flood variety are most commonly used. The sensitivity of the present-day camera tubes allows satisfactory indoor pickups with the amount of illumination existing for the event being transmitted, particularly in the case of sporting events such as wrestling, boxing, night baseball, and roller skating. Frequently, field events are simultaneously recorded on film by the press, and as a result more than enough light is thereby obtained for television use. Conventional spotlights may be used in a flood position when the lighting unit cannot be brought physically close to the subject being televised. Occasionally in banquet scenes and public assemblies, the main table or platform lighting is supplemented with incandescent spots and floods for general broad illumination, but the level seldom needs to exceed 200 footcandles of incident light and can be readily obtained without any serious difficulties.

In lighting an audience, incandescent floodlights are employed and levels of 75 to 125 footcandles have been found adequate.

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Deadline for Comments on C.I.E. Report November 1, 1951

All comments on the Recommendations contained in the Report on the Sessions of the International Commission on Illumination, held in Stockholm, Sweden June 26 through July 5, must be received by the U. S. National Committee, not later than November 1, 1951. Essentials of the Report are published on page 000 of this issue of ILLUMINATING ENGINEERING, and full multilithed copies may be obtained from the Secretary of the U. S. National Committee, C.I.E., Mr. L. E. Barbrow, c/o National Bureau of Standards, Washington 25, D. C. Comments on the Report should also be sent direct to Mr. Barbrow.

TELECAST

LIGHTING NEWS OF CURRENT INTEREST

Successful Sessions Held At the Stockholm Meeting of C.I.E.

Session XII of the International Commission on Illumination was held June 26 to July 7 in Stockholm, Sweden. As reported elsewhere in Telecast, Dr. Ward Harrison of the United States was elected International President.

At the opening general session, in the presence of King Gustav VI Adolf, 450 delegates from 22 countries, and 100 guests, a paper by Mr. Ralph Evans, Eastman Kodak Company, on Seeing, Light, and Color was presented by Dr. D. B. Judd, National Bureau of Standards.

Following the opening Session, parallel Sessions were held by the twenty-five Technical Committees of the Commission. Each of these Committees presented a technical report for discussion. In addition, forty-three papers were presented at the Sessions. It is of interest to note that five of the Technical Committee Reports were compiled by U. S. Secretariat Directors, and six of the papers were of U. S. origin. These were:

TC-7, Colorimetry (D. B. Judd, Sec. Dir.)

TC-23a, Lighting of Public Highways R. M. Zabel, Sec. Dir.)

TC-26e, Colors of Light Signals (F. C. Breckenridge, Sec.)

TC-62b, Lighting Practice (W. C. Brown, Sec. Dir.)

TC-63, Television (H. A. Kliegl, Sec. Dir.)

E. F. Lowry, The Engineering Evolution of the Fluorescent Lamp.

S. K. Guth, The Subjective Appraisal of Brightness.

R. L. Biesele, Daylight in Classrooms.

Myrtle Fahsbender, Two Decades of Residential Lighting in the United States.

R. G. Slauer, Space Concepts of Lighting.

C. M. Cutler, Creating a Selling Environment with Light.

Miss Fahsbender had the honor of being the first American woman to present a paper before the Commission.

The Sessions were too preoccupied with technical activity to permit partaking in the many attractive diversions which beautiful Stockholm has to offer in the first two weeks of summer. However, the delegates did participate in a number of entertainment features during available evenings. These included an informal reception and concert at the National Gallery of Art; supper-dance at the Grand Hotel Saltsjöbaden; dinner in the Gold Room of the City Hall; music and ballet at Old Drottningholm Theatre. During the Sessions, technical visits were made by many of the delegates. On Sunday, July 1, the delegates were favored with a ten-hour boat ride in the Stockholm Archipelago.

Unfortunately, meetings were scheduled through the day of July 4. However, as soon as the U. S. delegates in

View of banquet at the Gold Room in the architecturally famous Stockholm City Hall.

turn completed their work, they participated in a most enjoyable Independence Day program to which they were invited by the United States Ambassador to Sweden, Mr. W. Walton Butterworth. Arranged especially for their entertainment was a reception at Ambassador's residence, special ceremonies at Skansen, and a supper-dance at Hasselbacken. At Hasselbacken, upon invitation of the Ambassador, President Brainerd of the U. S. National Committee, C.I.E., explained the work of the Commission.

The results of the work transacted at the Technical Sessions will be published in a three-volume Proceedings. Some of the Recommendations which were adopted tentatively are abstracted elsewhere in the Telecast Section, this issue. Complete sets of the tentatively approved Recommendations may be obtained from the Secretary of the U. S. National Committee, Mr. L. E. Barbrow, National Bureau of Standards, Washington 25, D. C.

The recommendations have been only tentatively approved but they will become effective six months after their tentative approval unless objection is entered by any National Committee. Anyone desiring to comment on or object to any of the proposed recommendations should communicate with Mr. L. E. Barbrow promptly.

King Gustav of Sweden (right), who attended the general opening session of the C.I.E. meeting, with Honorary President N. A. Halbertsma.

Eighteen delegates from the United States attended the Stockholm meetings, all of them well-known and active I.E.S. Members. United States delegates attending were:

C. A. Atherton, Westinghouse International Corp.

Isay Balinkin, University of Connecticut

L. E. Barbrow, National Bureau of Standards

A. A. Brainerd, Philadelphia Electric Co.

F. C. Breckenridge, National Bureau of Standards

W. C. Brown, General Electric Company

C. M. Cutler, General Electric Company

H. Deming, International General Electric Company

M. Fahsbender, Westinghouse Electric Corp.

S. K. Guth, General Electric Company

W. Harrison, Consulting Engineer

S. G. Hibben, Westinghouse Electric Company

D. B. Judd, National Bureau of Standards

R. A. Manwaring, Philadelphia Electric & Mfg. Co.

R. C. Putnam, Case Institute of Technology

F. J. Vorlander, Champion Lamp Works

W. C. Wagner, Philadelphia Electric Co.

T. D. Wakefield, F. W. Wakefield, Brass Co.

Officers of the United States National Committee of I.C.I. are Arthur A. Brainerd, President; Willard C. Brown, Vice-President, and Louis E. Barbrow, Secretary-Treasurer.

Comments on Recommendations of Report On C.I.E. Sessions Due November 1, 1951

Comments on the Recommendations made in the Report on the International Commission on Illumination held this summer in Stockholm, Sweden must be received by the U. S. National Commission by November 1, 1951. Secretary of the Commission is Mr. L. E. Barbrow, National Bureau of Standards, Washington, D. C.

The entire report in mimeographed form may be obtained on request from Mr. Barbrow, and those wishing to submit comments are urged to send for a copy promptly. The Report contains recommendations from the committees listed below; essentials of some of the recommendations are also given.

Committee 1b—Definitions

It is recommended that the word luminance (or a similar word) should be used in every country.

The C.I.E. proposes that where the metric system is used, the unit of illumination should preferably be the lux, and the unit of luminance the nit.

The word emittance (luminous emittance or radiant emittance) is proposed for the flux emitted per unit area.

The letter Q (and not L) should be used for the symbol representing the quantity of light.

The definitions proposed in resolution 8 of Committee 7 (Colorimetry) are recommended by Committee 1b.

Revised definitions are adopted (See full Report for recommended definitions.)

(a) Radiant flux
(b) Luminous flux
(c) Luminous efficiency (of a radiation)
(d) Relative luminous efficiency (of a monochromatic radiation)
(e) Illumination (at a point of a surface)
(f) Luminous emittance (from a point of a surface)
(g) Luminous intensity (in any direction)
(h) Luminance (at a point of a surface and in any direction)
(i) Candela (Symbol: cd)
(j) Lumen (Symbol: lm)
(k) Lux (Symbol: lx)
(l) Nit (Symbol: nt)

Committees 2 and 3, Units and Standards

It is recommended that the Bureau of the C.I.E. should contact B.I.P.M. and attempt to establish uniform methods for realizing in practice certain standards already proposed by the B.I.P.M. (See full Report for Standards).

Committee 4, Light and Vision

It is recommended that, when the relative luminous effects produced by radiation of different wavelengths on the young dark-adapted human eye near the threshold in extrafoveal vision are to be determined, the following relative luminosity values should be used. These values define the "1951 C.I.E. Scotopic Luminosity Function for Young Eyes," and will be denoted by the symbol V'_λ. (The values are actually given as $\log_{10} V'_\lambda$.) See also full Report.

The values adopted in the recommendation are intended to represent as nearly as possible the mean spectral sensitivity of the red mechanism for subjects whose age does not exceed 30, when observing at angles of not less than 5° from the foveal center under conditions

of complete dark adaptation. It must be realized that the values for an individual will in general show differences from the standard, which may be very large at wavelengths below 400 mμ.

For subjects of age more than 30, the limited information available indicates a tendency for the values in the blue end of the spectrum to be lower. For an estimate of the average magnitude of this change, see the Secretariat Report 4.

Committees 5, 6, Photometry

It is recommended that stable electric discharge lamps, including fluorescent lamps, should be developed for use as photometric sub standards. Such lamps may have either the same geometric form and size as commercial lamps or other forms developed specially for this purpose.

While regarding with satisfaction the notable progress in the field of photometry, it is considered that the recommendations adopted at the eleventh session (1948) remain adequate for the future development of the work of the Commission and should be confirmed.

Committee 7, Colorimetry & Artificial Daylight. (See also full Report)

1. It is recommended that the definition of standard source A be changed to read:

> "A. A gas-filled tungsten-filament lamp, operating at a color temperature of 2854°K according to the International temperature scale of 1948."

For calculations of spectral energy distribution, the constant C2 of Planck shall be taken as 14380 micron degrees. In the event of an alteration in the value of C_2 the color temperature T of the lamp shall be changed so that $T/C_2 = 2848/14350$ (approx. $= 2854/14380$)/

Definitions for Dominant Wavelength, Complementary Wavelength and Chromaticity are submitted to Committee 1b for adoption: (See full Report for recommended definitions.)

Committee 21, Light Sources (See also full Report.)

It is recommended that all member countries should accumulate data on the color and color rendering properties of electric discharge lamps particularly all classes of the fluorescent "white" colors, using the method of measurement agreed by the C.I.E. in 1948. These measurements should be made together with lumens per watt measurements on fluorescent lamps after they have been aged for 100 hours.

Committee 22a, Diffusing Materials (See also full Report.)

Secretariat 23a, Lighting of Public Highways (See also full Report.)

It is recommended that National Committees should increase their efforts to establish a simple and practical method of predetermining and appraising the quality of public lighting installations and of comparing them with one another.

Committee 23b, Automobile Headlights (See also full Report.)

1. It is resolved that the type E headlight as chosen by the Arnheim Selection Committee be accepted as the type of headlight most representative of current European practice.

2. It is recommended that the work on automobile lighting (headlights, marker lights, signal lights, etc.) be continued by Committee 23b during the interval between this meeting and the next C.I.E. meeting. A list of the items which should be included in this work is included in the full Report.

Committee 25a, Museum Lighting (See full Report.)

Committee 25b, Architectural Lighting (See full Report.)

Committee 26a, Aviation Ground Lighting (See full Report.)

Committee 26b, Aircraft Lighting (See full Report.)

Committee 26c, Traffic Signals (See full Report.)

Committee 26A, Calculation of Intensities of Projectors (See full Report.)

Committee 26e, Colour Specification for Light Signals (See full Report.)

Committee 27, Natural Daylight (See also full Report.)

1. It is recommended that before the next session of the C.I.E., the countries interested in natural lighting should consider in detail (a) the distribution of sky brightness according to country; time of day and year, and (b) reflected daylight. Consideration should be given to calling the sub-committee together in 1953, or sooner if deemed advisable, to discuss progress.

Committee 29, Mine Lighting

It is recommended that specific subjects (see full Report) should be studied prior to the next session of the C.I.E.

It is recommended that the National Committees should prepare Codes of Practice for Mine Lighting, and that these Codes be compared at the next session of the C.I.E.

Committee 41, Ultra Violet Radiation (See full Report.)

Committee 62a, Lighting Education (See full Report.)

Committee 62b, Lighting Practice (See also full Report.)

1. It is desirable that Codes of Recommended Illumination Values should have common bases. To this end it is recommended that the member nations of the C.I.E. should consider the basis of visual performance and ease of seeing adopted in the British I.E.S. Code. The illumination values given in that Code are based on a visual performance of reasonably high standard. It is recognized

(Continued on page 9A)

Be It Resolved

upon the recent passing of Earl W. Fowler that the officers and Council of the Illuminating Engineering Society hereby express their appreciation and gratitude for the many contributions which Mr. Fowler made to the field of lighting and to the Society in particular.

The progress of the Western New York Section during the formative years was greatly facilitated by Mr. Fowler's ability to bring together various elements of the lighting fraternity when he served as Secretary and Chairman for three years.

Not only did he have organizational ability but he was above all concerned with the technical and professional progress of the Society as a whole. It was his concern that the Society's technical reports be sound and carefully developed. He played a leading part in the development of recent reports on Office, Store and Industrial applications. His contribution in the Niagara Award paper "Glare and Lighting" demonstrated his ability to this end.

His particular abilities equipped him well to serve as a leader on key Society Committees. Therefore, his untimely passing leaves a serious gap in the ranks of those who are seeking to forge a better and stronger Society.

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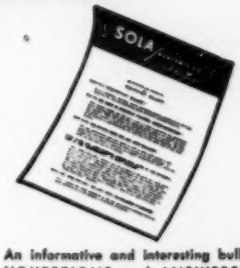

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(*Continued from page 7A*)

that the standard of visual performance adopted as a basis by other nations may vary due to economic and other causes.

2. At the high levels of illumination now being used, comfort is becoming increasingly important in visual problems.. It is therefore recommended that member nations should examine all new experimental data to determine whether it is possible to adopt standards of practice for desirable, or permissible, brightness and color relationship.

Committee 62c, Voltage Variations (*See full Report.*)

Committee 62d, Screen Lighting in Cinemas (*See full Report.*)

Committee 62e, Lighting of Theatre Stages (*See full Report.*)

Committee 63, Television

1. It is desirable that each interested country, prior to the next session, should propose a report covering lighting developments in the field of black and white television (lighting of the studios and for reception).

2. It is suggested that a special subcommittee be appointed to deal with color television.

3. It is desirable to collect information dealing with the ambient lighting used when viewing.

4. It is desirable to propose in collaboration with the transmission authorities, instructions for the use of televiewers, which will enable them to adjust their receivers to give the best reception.

5. It is desirable that a thorough study should be made with the object of improving the quality of films used in television.

6. It is desirable that a study of visual fatigue due to viewing be made in each country in collaboration with the appropriate medical body.

Dr. Ward Harrison Elected President of C.I.E.

At Session XII of the International Commission on Illumination held in Stockholm, Sweden, June 26 to July 7, 1951, Dr. Ward Harrison was elected President of the Commission for the four-year period ending in 1955, when Session XIII will be held in Switzerland.

Other officers elected were:

N. A. Halbertsma (Netherlands)	*Hon. President*
J. W. T. Walsh (Great Britain)	*Vice-President*
M. Leblanc (France)	*Vice-President*
I. Folcker (Sweden)	*Vice-President*
H. König (Switzerland)	*Hon. Treasurer*
C. A. Atherton (United States)	*Hon. Treasurer*

Dr. Harrison has been recognized throughout the world, for many years, as a most distinguished figure in the field

Dr. Ward Harrison

of illumination. Already honored with almost every award possible in the United States, his fame and distinction have also been recognized and respected abroad. In 1947 he was invited to give the principal address at the 1948 Summer Session of the Illuminating Engineering Society of Great Britain, an invitation extended only as an important honor. Last year, Great Britain conferred an additional honor on Dr. Harrison, electing him to Honorary Member, a jealously guarded award in their Society.

In the United States, Dr. Harrison has throughout his career been one of the most respected men in the profession of illuminating engineering. The first Honorary Doctorate in Illumination was conferred on him in 1940, by the Case School of Applied Science. He has served as President of the Illuminating Engineering Society (1922-1923), is a Fellow of I.E.S., and has received the Society's highest honor, the I.E.S. Gold Medal (1949) "for meritorious achievement conspicuously furthering the profession, art, or knowledge of illuminating engineering."

Until his retirement a few years ago, Dr. Harrison was Director of Engineering, Engineering Division, Lamp Department, General Electric Company, at Nela Park, Cleveland, Ohio. Since that time his career has continued, as a Consulting Engineer in that city.

C.I.E. Central Bureau Office at I.E.S. Headquarters

One of the offices at the new I.E.S. headquarters at 1860 Broadway, New York is now the permanent quarters for the Central Bureau of the International Commission on Illumination. Miss Audrey Wiggins, Assistant to the Honorary Secretary, C. A. Atherton, moved in August 1st, on her return from Stockholm, where she attended the I.C.I. Sessions this summer.

Nominations Invited For I.E.S. Gold Medal Award

The I.E.S. Medal is awarded for the purpose of giving recognition to meritorious achievement which has conspicuously furthered the profession, art or knowledge of illuminating engineering. In making nominations for the Award, the following points should be observed.

1. Candidates for the award need not be members of the Society, nor citizens of the United States or Canada, and may be nominated at any time by any member of the Society, by presenting to the General Secretary at Society Headquarters the name of the individual whose accomplishments in his field are deemed worthy of such recognition, whether it be in the field of engineering, design, applied illumination, optics, ophthalmology, lighting research education, or administration and management.

2. In order for a candidate to be considered for the award of a given year, a letter requesting consideration of the proposed candidate shall be delivered at the General Office before January 1 of that year.

3. Nominations and records on file in the General Office from previous years, as reviewed and referred to the next year's committee by the previous Medal Award Committee, will be given consideration along with any new nominations.

The I.E.S. Gold Medal, established in 1944, accompanied by an appropriately engrossed certificate of award has been presented to the following: George H. Stickney, Preston S. Millar, E. C. Crittenden, Matthew Luckiesh, Sir Clifford Paterson, Ward Harrison and William F. Little. No award was made in 1951.

IT SEEMS TO ME

Projection Screen Surroundings

To the Editor:

My article on Lighting Projection Screen Surroundings (ILLUMINATING ENGINEERING, July, p. 361) went to press too soon to include a reference to an important addition to our basic data on this subject, namely, a paper by Sylvester K. Guth of Nela Park, entitled "Surround Brightness: Key Factor in Viewing Projected Pictures" given before the Society of Motion Picture and Television Engineers at New York, May 2, 1951. This gives the results of a laboratory research at Nela Park which explores some of the things I mention in

(*Continued on page 12A*)

SAVE

You can now

Effective immediately, Westinghouse fluorescent lamps will be sold at new, greater discounts to quantity buyers. All types and sizes of fluorescent lamps come under this money-saving order: standard fluorescent tubes, slimlines, and circlines—you save on all!

In quality, these lamps remain unsurpassed! Their end-to-end brightness, their uniformity of color, and, above all, their dependable performance for thousands of hours add up to value that is not topped.

So, whether you buy a few tubes or a few thousand, whether you are a regular Westinghouse customer, or a prospect, take advantage of these important savings.

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None burns brighter, none lasts longer than Westinghouse fluorescent lamps. For factories, stores, offices, schools or public buildings, their *lifetime* record is tops.

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Since the introduction of Westinghouse fluorescent lamps, light output has been steadily increased, life lengthened, and price reduced. Today's new discounts are new, added proof of Westinghouse progress in lamp leadership.

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Measured by any yardstick, whether quality of light output or lamp life, there's no better value for the money.

For details, call or write the Westinghouse sales office nearest you. See list at right. Westinghouse Lamp Division, Bloomfield, New Jersey.

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Allentown	730 Hamilton St.	4-5108
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Atlanta	(Chamblee, Ga., 2260 Peachtree Ind. Blvd.)	21-3141
Baltimore	501 St. Paul Pl.	Plaza 0300
Birmingham	P. O. Box 1814	Homewood 2-7892
Boston	(Belmont, Mass., 30 Brighton St.)	BE 5-6020
Buffalo	814 Ellicott Sq. Bldg.	Washington 3986
Charlotte	1900 Liberty Life Bldg.	4-6624
Chicago	Whitehall 4-3060	
Cincinnati	Garfield 2250	
Cleveland	Cherry 1-7600	
Columbus	Main 5527	
Dallas	Randolph 4161	
Davenport	3-2761	
Dayton	Adams 9153	
Denver	Keystone 8121	
Des Moines	2-0244	

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Cleveland	1370 Ontario St.	Cherry 1-7600
Columbus	262 N. 4th St.	Main 5527
Dallas	209 Browder St.	Randolph 4161
Davenport	2212 E. 12th St.	3-2761
Dayton	32 N. Main St.	Adams 9153
Denver	910 15th St.	Keystone 8121
Des Moines	1408 Walnut St.	2-0244
Detroit	5757 Trumbull Ave.	Trinity 2-7010
Ft. Wayne	610 S. Harrison St.	Anthony 3421
Ft. Worth	1310 Electric Bldg.	Fortune 4885
Hartford	119 Ann St.	5-6851
Houston	1314 Texas Ave.	Charter 4801
Huntington, W. Va.	1029 7th Avenue	7146
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Milwaukee	538 N. Broadway	Daly 8-1800
Minneapolis	727 2nd Ave., N.	Main 1471
Nashville	2908 Woodlawn Dr.	9-9560
New Haven	42 Church St.	5-3191
New Orleans	238 So. Saratoga St.	Tulane 6891
New York	40 Wall St.	Whitehall 3-4321
Newark	528 Ferry St.	Mitchell 2-3450
Oklahoma City	120 N. Robinson St.	7-1633
Omaha	117 N. 13th St.	Harney 8-700
Peoria	114 Callender St.	8-533
Philadelphia	3001 Walnut St.	Evergreen 2-1200
Pittsburgh	337 Blvd. of Allies	Atlantic 1-8400
Pittsburgh	McKee & Leonard Sts.	Federal 1-9962
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Providence	51 Empire St.	Gaspee 1-0818
Richmond	1110 E. Main St.	2-4756
Roanoke	Kirk Ave. & 1st St.	6263
Rochester	1048 University Ave.	Monroe 1635
Sacramento	1720 14th St.	Gilbert 3-6525
Saginaw	124 S. Jefferson St.	Saginaw 4-2640
St. Louis	411 N. 7th St.	Central 1120
Salt Lake City	235 W. South Temple St.	5-3413
San Antonio	115 W. Travis St.	Garfield 5114
San Diego	861 6th Ave.	Main 8151
San Francisco	410 Bush St.	Exbrook 2-5353
Seattle	1200 Westlake Ave., N.	Garfield 2133
Spokane	1023 W. Riverside Ave.	Main 3294
Springfield	76 Vernon St.	6-8373
Syracuse	700 W. Genesee St.	2-1361
Tampa	405 Wallace S. Bldg.	2-8298
Tulsa	600 S. Main St.	3-3191
Washington, D. C.	1625 "K" St., N. W.	National 6843
Wichita	301 S. Market St.	5-2631
Wilkes-Barre	267 N. Pennsylvania Ave.	3-1144

(Continued from page 9A)

my article as being in special need of exploration. It should be studied by all who are especially interested in this subject.

Space does not permit an adequate abstract, but a few points may be mentioned. By an ingenious laboratory set up the visual surrounding conditions of a person seated in a movie theater were simulated, except that the observer could vary both the border brightness (the border being the area between the picture and the edges of the projection screen) and the surround brightness, so as to make either of these what the observer preferred for the picture being shown. It was found that the surround brightness had no significant effect on the selection of border brightness provided it was equal to or less than the latter. (The dimensions of the border are not given. In practice it may be wide or narrow.) None of the observers desired a zero surrounding brightness. The general preference was for about one-half the border brightness. All who viewed the projected pictures indicated that border brightness was of the greater importance. The results given later are for border brightness. A range of picture brightness from 0.1 to 6 footlamberts was explored. The firm used had an average transmission of 10 per cent for the whole film but with a range of from 1 per cent minimum to 25 per cent maximum. The results given were from five observers, each of whom ran a series; with unlimited time to select the border brightness deemed best. With a picture brightness of one footlambert the preferred border brightness was about 0.46 footlambert; with 0.1 footlambert picture brightness, 0.12 for the border; with 6-footlambert picture brightness, 1.1 for the border. The laboratory set-up used eliminated all non-projected or stray light on the screen. A brief investigation to determine the amount of stray light on the screen which would have a barely perceptible effect on picture quality showed that with a picture brightness of 0.5 footlambert a brightness of about 0.07 footlambert produced by stray light had no effect on the picture. With a 3-footlambert picture brightness the stray brightness could be 0.15 footlambert. Permissible stray light brightness of about one-fifth the border brightness was found best.

From these figures of Mr. Guth's, it is evident that a desirable border brightness can not be attained by the use of non-projected light alone, without harming the pictures. The logic of advanced designs, such as Fig. 5 of my article, is substantiated. With such designs, with a picture screen only large enough to take the picture with a reasonable margin of safety, the most of the picture surround becomes controllable as to brightness, independently of the stray or general lighting of the auditorium.—JAMES R. CRAVATH, *Berkeley, Calif.*

To the Editor:

In glancing through the July issue of ILLUMINATING ENGINEERING, I found an article signed by J. R. Cravath. I turned a few pages to see if the "discussion" was by A. D. Curtis, C. E. Ferree (communicated) or possibly by A. J. Sweet, and then awakened with a start to the realization that it is 1951 and not 1914. I was happy to read the footnote "The author . . . now retired and living at . . ."

I want to express the hope that Mr. Cravath's retirement will result in more papers and articles on lighting. I remember the tremendous amount of pioneering work he did on glare and its elimination. I feel that the Society will be much further advanced if he continues his work in illumination.—LYMAN DAY MORGAN, *Pacific Northwest District Manager, Pittsburgh Reflector Co.*

ABOUT PEOPLE

B. Allen Benjamin has been elected Vice President and Secretary of the Benjamin Electric Mfg. Co., Des Plaines, Ill. taking on the supervision of the Engineering Department as well as continuing to act as chairman of the Merchandising Committee and heading Planning and Material Controls. Also announced was the appointment of **Arthur E. Swedenborg** as Assistant General Sales Manager with headquarters in Des Plaines.

Frank Thornton, Jr., manager of engineering association activities for Westinghouse Electric Corp. since 1931, has retired after 42 years with the company. He will be succeeded by **Hendley Blackmon**, who has been assistant manager.

Harry L. Erlicher, Vice-President of General Electric Company, has been named special assistant to the Under Secretary of the Army, Archibald S. Alexander. Mr. Erlicher will be in charge of Army procurement and production expediting in the office of the Under Secretary.

Paul T. Onderdonk, engineer with Consolidated Edison Company, has been elected president of the Technical Societies Council of New York, an affiliate of the local sections of 17 technical societies in the area.

New officers elected by the Fluorescent Lighting Association are: Bruce Todd, President; Rudy Hultgren, Vice-President; Harry Weiss, Treasurer; Bert Pretzer, 2nd Vice-President, and Don Ingwersen, Secretary.

The Board of Directors of the Electrochemical Society have announced that the first Palladium Medal Award will be presented to **Dr. Carl Wagner,** Visiting Professor of Metallurgy, Massachusetts Institute of Technology, at their fall meeting, October 9-12. The award is being given for his contributions in fundamental electrochemistry and work with corrosion problems.

The Miller Company, Meriden, Conn. has appointed **L. M. Grawemeyer** as sales manager of the Illuminating Division of that company.

Robert E. Jordan has been named manager of the General Electric Lamp Division's Niagara Sales District, with headquarters at Buffalo, N. Y., it was announced recently. He succeeds **Harry E. Huff,** who died in Buffalo of a heart attack July 15, after having been manager of the district since 1941. Mr. Jordan has served in the lamp sales field in upper New York state for many years.

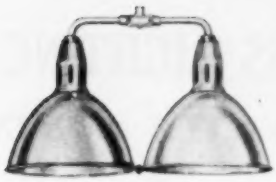
E. L. Dodington, recently elected Secretary of the Toronto Section of I.E.S., has accepted a position with the Sterling Electrical Company, St. Catharines, Ontario, and has had to resign as Secretary of the Section. **D. J. McKenzie** of the Toronto Hydro Electric System has been appointed to serve in that office.

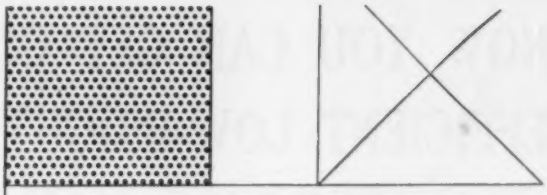
Edmund C. Schorr has been appointed manager of sales of General Electric's Specialty Transformer and Ballast Department at Fort Wayne, Indiana. Mr. Schorr, an active member of I.E.S., assumed his new duties September 1.

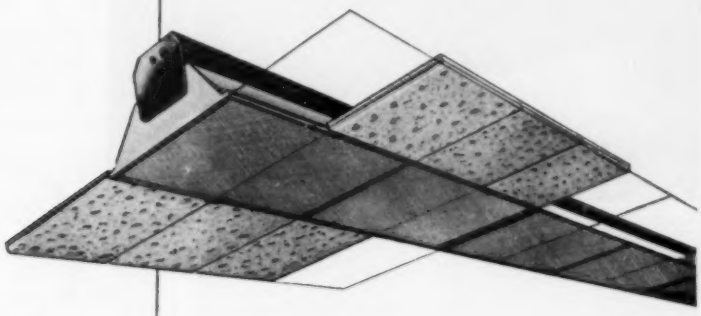
BOOKS AND PAMPHLETS

Colours and How We See Them by Hamilton Hartridge, published by G. Bell & Sons, Ltd., London, 1949; available in the U. S. from British Book Centre, 122 East 55th Street, New York City; 169 4¾ x 7⅝ inch pages, 39 black and white illustrations, 12 colored plates; price $3.50.

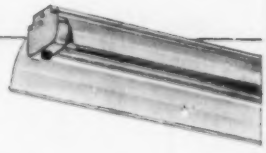
(Continued on page 39A)







WHY MILLER RATES YOUR CONSIDERATION WHEN YOU ARE PLANNING LIGHTING



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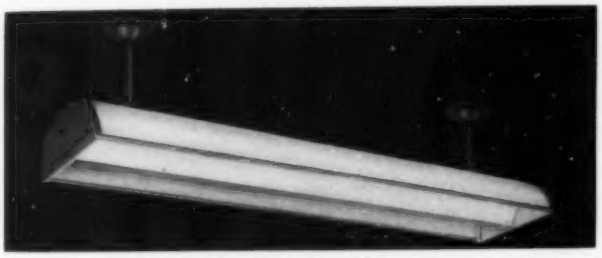

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. . . **Maximum lighting efficiency**

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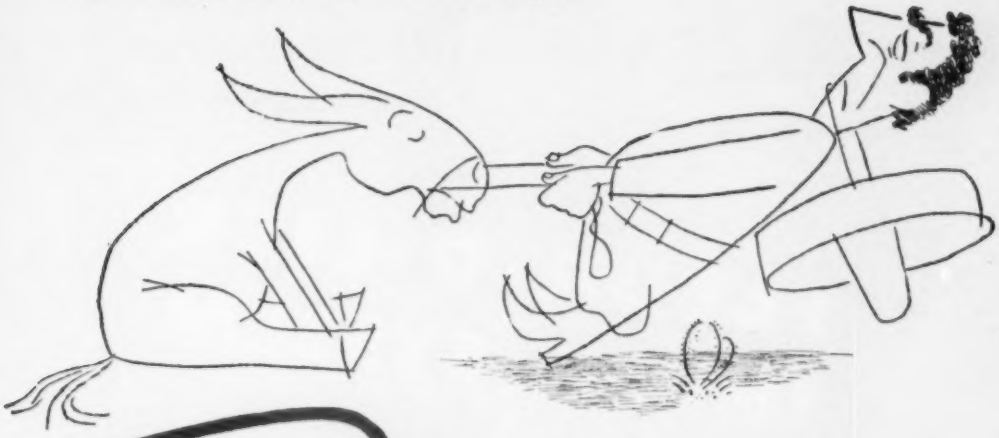

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These starters eliminate blinking and flickering of lamps which have reached the end of their useful life, thereby protecting the ballast and prolonging the life of the starter.

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AUTOMATIC RESET

(Restores the circuit as soon as new lamp is inserted.)

Two pin—for 40, 85, 90 and 100 watt lamps.

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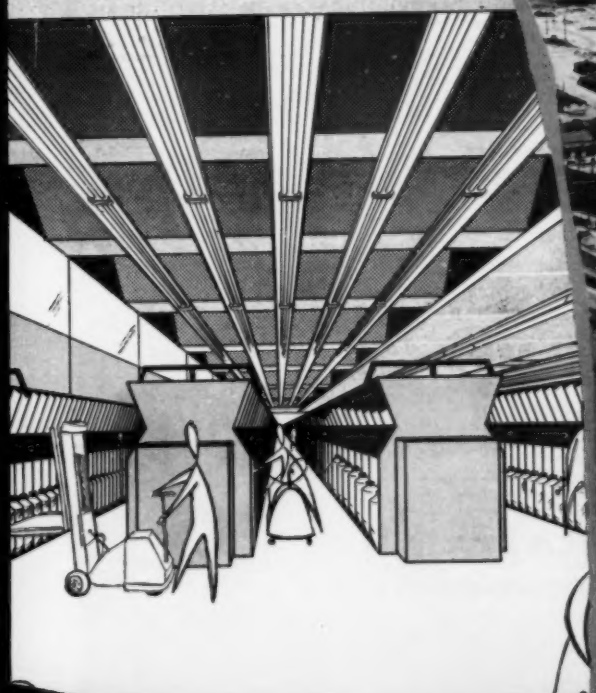

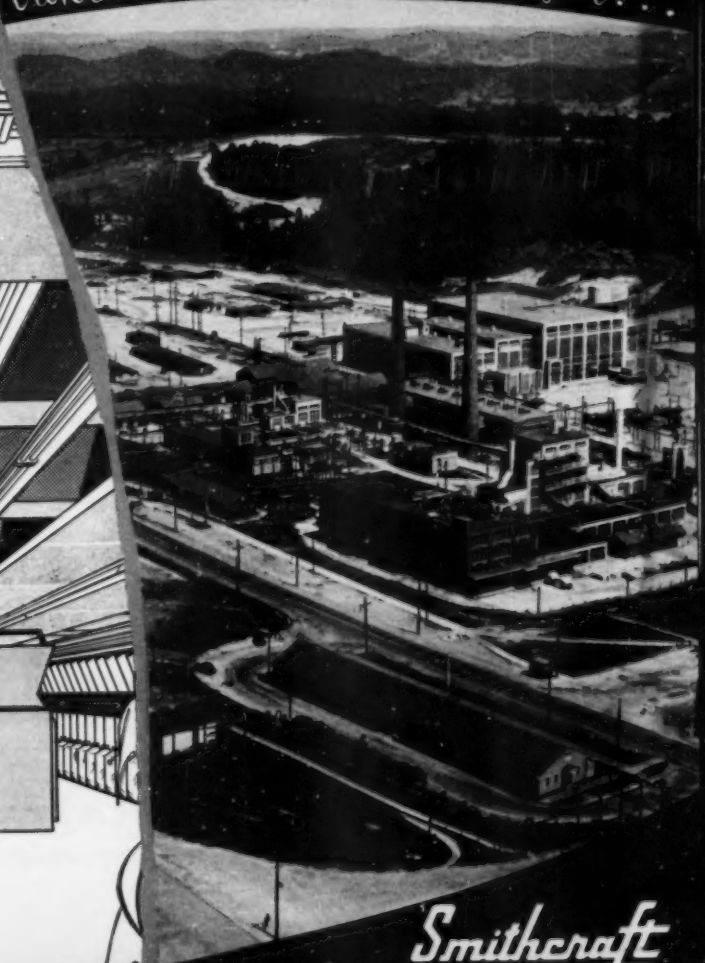

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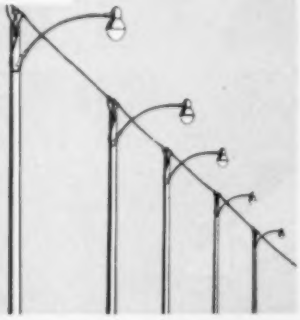

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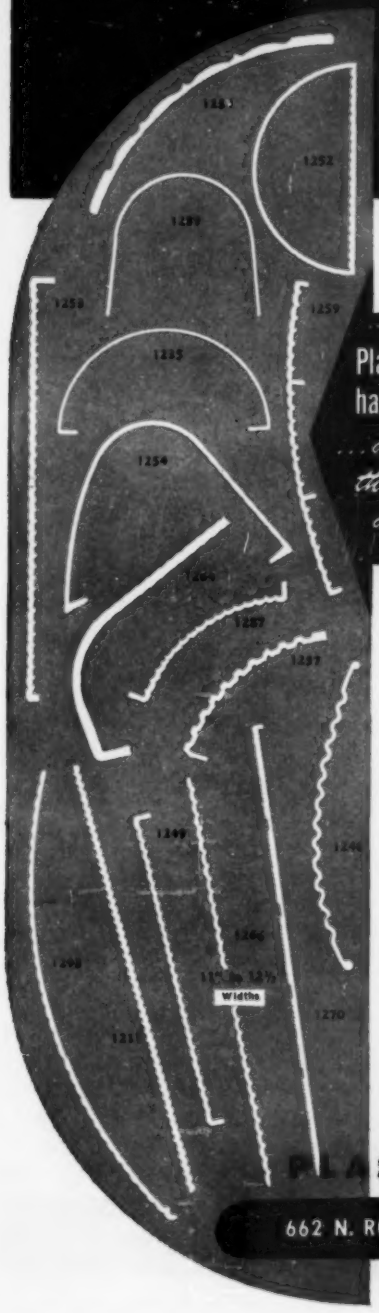

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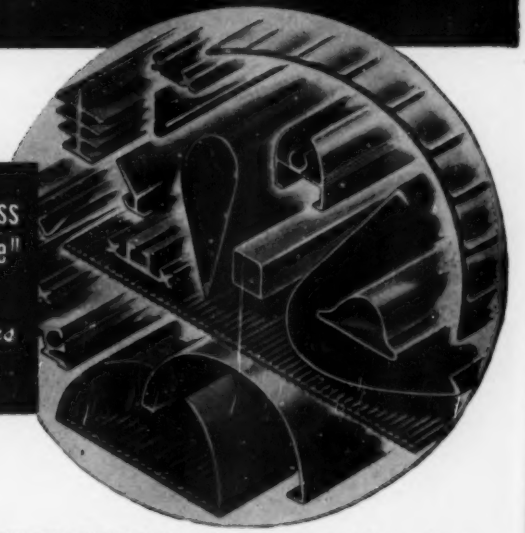

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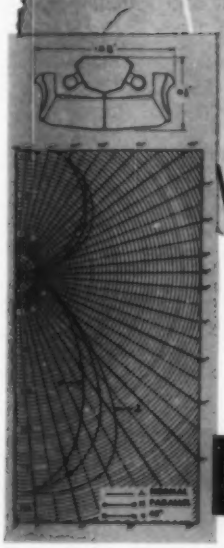

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AT THE Murphy Paint Company Limited, Toronto, Ontario, Canada, the ‡PC Vision-Lighting Plan, utilizing PC *Functional* Glass Blocks, effectively complements the electric lighting plan. Here, protective lighting at night is afforded on surrounding yards. And by day, floods of scientifically directed daylighting are admitted. Architect: J. C. Meadowcroft, Montreal, Quebec, Canada.

‡*The PC Vision-Lighting Plan consists of orientation-keyed areas of PC Functional Glass Blocks —selected for sun or non-sun exposure—used with vision-ventilation areas as required.*

THIS NEW Technology Building, Orange Coast College, Costa Mesa, Calif., utilizes clerestory panels of PC Soft-Lite* Prism B Glass Blocks in bilateral daylighting of classrooms. Thus, they help achieve an ideal lighting plan, in conjunction with electric lighting. Architect: Robert E. Alexander, Los Angeles, Calif.

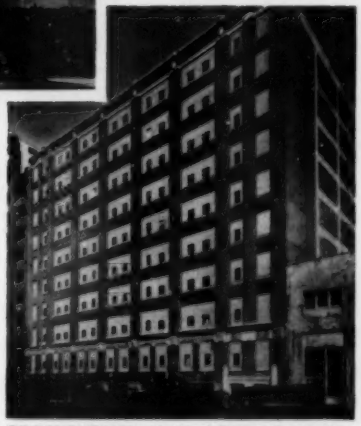
**T. M. Reg. Applied For.*

● In schools, offices and plants, whether lighting new buildings or re-lighting old ones, PC *Functional* Glass Blocks complement electric lighting. They help create comfortable, low-brightness ratios and adequate illumination levels during daylight hours, conforming to illuminating engineering and architectural standards.

Installation is easy and quick. And on-the-job cleaning is expedited by the new PC "Clean-Easy Face Finish."

PC Glass Blocks help maintain proper temperature and humidity levels, because they have more than twice the insulating value of ordinary glazing. They reduce heating and air-conditioning costs. They involve no wood or metal sash, so there is no periodic repairing, painting and puttying. Normal rainfall and routine maintenance preserve their high light transmittance. And PC Glass Blocks are immediately available.

For complete information on PC Glass Blocks, fill in and return the coupon.



THE MODERNIZATION of the Lura Building in New York City included the replacement of large areas of outworn window sash with panels in which PC Glass Blocks were combined with modern ventilation units.

PC Glass Blocks are immediately available . . . no construction delays!

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Without obligation on my part, please send me your FREE booklet on the use of PC Glass Blocks in industrial, commercial and public buildings.

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Distributed by Pittsburgh Plate Glass Company; W. P. Fuller & Co. on the Pacific Coast; Hobbs Glass Ltd. in Canada; and by leading distributors of building materials everywhere.

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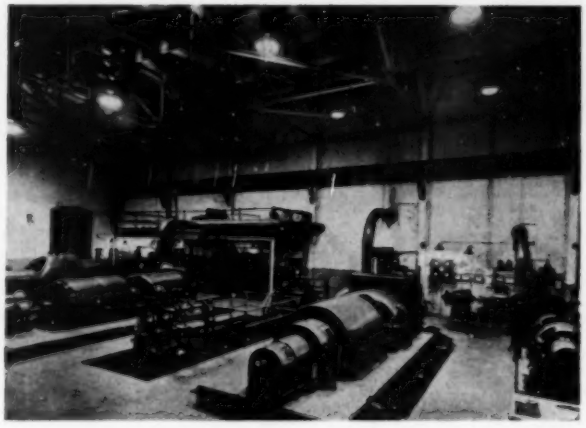

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ELECTRO LUSTREX Styrene Louvers are guaranteed to remain warp-free under ordinary conditions of use.
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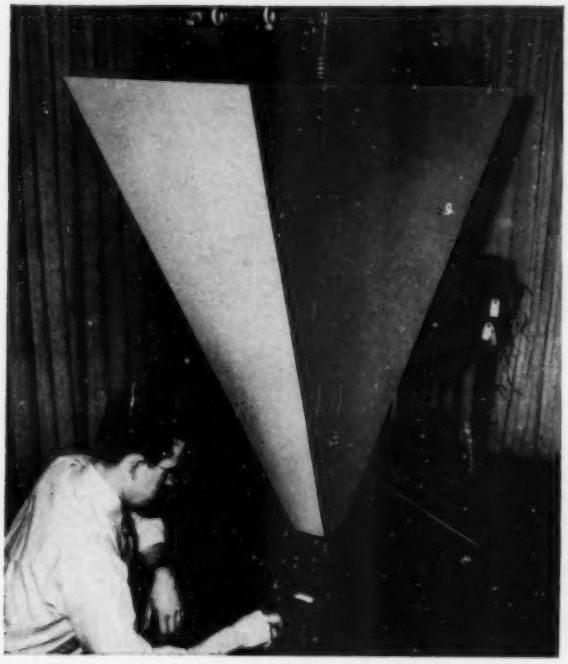

G-E engineer puts ballast through series of rigid tests. Constant attention to sound levels by G.E. helps you minimize the noise problem.

*SOUND-RATING: G.E.'s new classification of ballasts to guide you in the correct application of fluorescent fixtures.

A new tool to help you build greater customer satisfaction

Every fluorescent ballast has a normal, magnetic hum. But now, for the first time, you can know the relative sound level of the ballast before you buy. For G-E engineers have pioneered a system for measuring ballast sound levels accurately. These measurements have led to six classifications: from "A"—extremely quiet, to "F"—quite audible. This means that you know, before installation, which ballasts are right for any given application—whether it be church, school, noisy factory area, or any one of a wide range of other locations.

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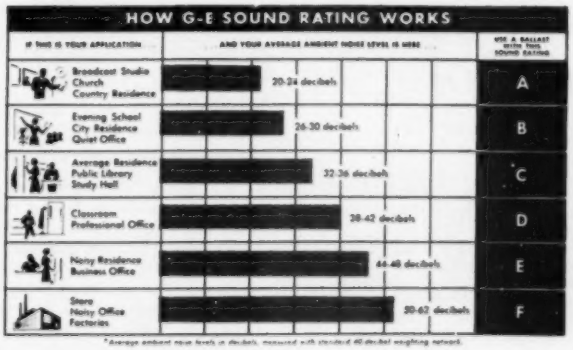

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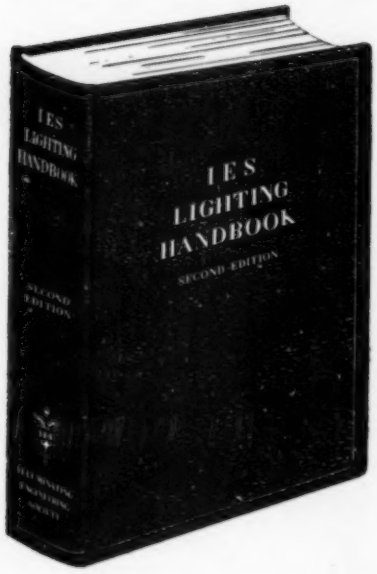

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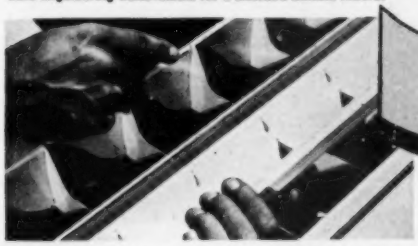

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The principal source of light is five large pendant fixtures above the main chamber floor and six smaller hanging fixtures above the galleries. These are designed to give direct, indirect and diffused light. Supplementary lighting is concealed above the deeply coffered ceiling and consists of twelve RAMBUSCH Rotospots accentuating the rostrum and forty-six RAMBUSCH Downlites covering the floor area. Dimmers have been installed making it possible to regulate the level of lighting from zero to sixty foot-candles providing adequate facilities for television photography.

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Last year we started out with both 4- and 8-ft. slimline — and 4-ft. has won by a landslide! Sales have zoomed higher than anyone had expected. Lighting men everywhere have fallen in love with GUTH 4-ft. Slimline. Here's what some say:

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"My clients are still praising me for suggesting convenient, short GUTH 4-ft. Slimlines. Gives them all the economy and functional advantage of Slimline lighting without the clumsy 8-ft. length."

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4-Ft. Slimline now available in every 2- and 4-lamp fixture in the entire GUTH line! See your GUTH resident engineer, or write for Bulletin 871-I giving full details.

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Lighting should help make merchandise look its best *besides* adding decor to the surroundings. That's why CORNING "Light-Weight" Lens Panels were specified for the new Brooklyn unit of Lane Bryant Stores.

Corning's new clear crystal glass assures high lighting efficiency. It transmits the true color of the light source—especially important where fine fabrics are displayed. Back surface fluting cuts down end and side luminaire brightness. Fresnel design lenses distribute light evenly.

CORNING Lens Panels add special beauty to any installation. Single panels available for fixture openings of varying lengths eliminate unsightly joints. This feature streamlines appearance, does away with light leakage, and permits more design flexibility. And these are the lightest weight lenses on the market today—weighing only 1½ lbs. per running foot (11 inches wide). This makes possible lighter, less expensive fixtures and lower shipping costs.

In fact, CORNING Lens Panels cost less all around—less to buy, less to install . . . less to clean. Find out more about CORNING "Light-Weight" Lens Panels and what they can do for you. Write for information today.

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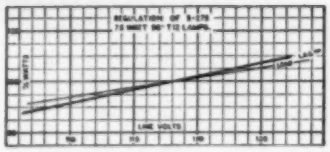
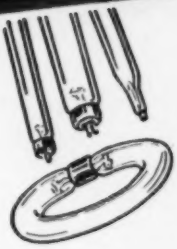




Because . . .

Quiet operation is assured with Advance Ballasts due to the method of riveting shell type units. All points of magnetic stress are securely riveted minimizing noise during service.

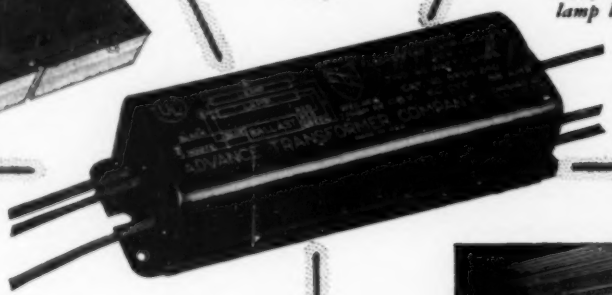
Because . . .

Special circuits in Advance Ballasts insure better regulation with varying voltage and equal light output per lamp.

Because . . .

Every step is taken to maintain lamp current wave shape as close to sinusoidal as possible, thus assuring longer lamp life.

Vacuum impregnation insures longer ballast life.



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Our patented construction affords weight saving as high as 30% for the 96" T-12 Two-Lamp ballast at 430 m. a. The lightest ballasts available for independent stroboscopic corrected lamp operation.

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SLIMLINE BALLASTS

Because . . . *A continuous "Accelerated Life Test" of vital materials maintains unvarying quality.*

And Because . . . *Advance Transformer Company is constantly striving to increase the efficiency of fluorescent ballasts which effects savings for you and your clients.*

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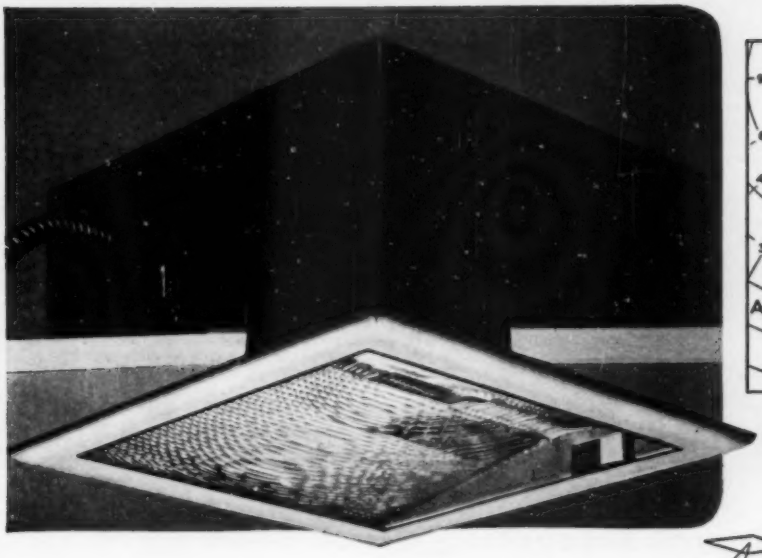
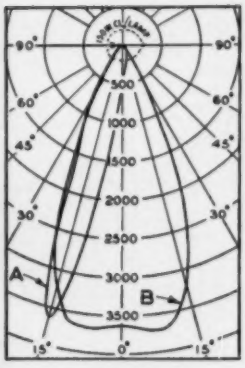
Featuring CONTROLENS* *with Concave Cross Section*





"A"—Vertical Distribution in Plane of Offset
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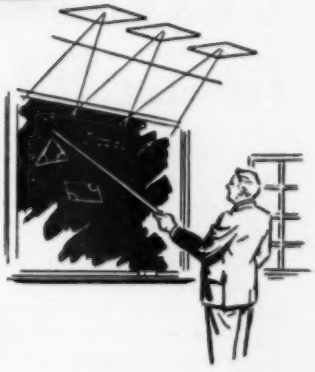

For engineering details, specifications, installation and spacing information as well as tables determining initial illumination on vertical surfaces, write for DS-34, No. 798 folder.

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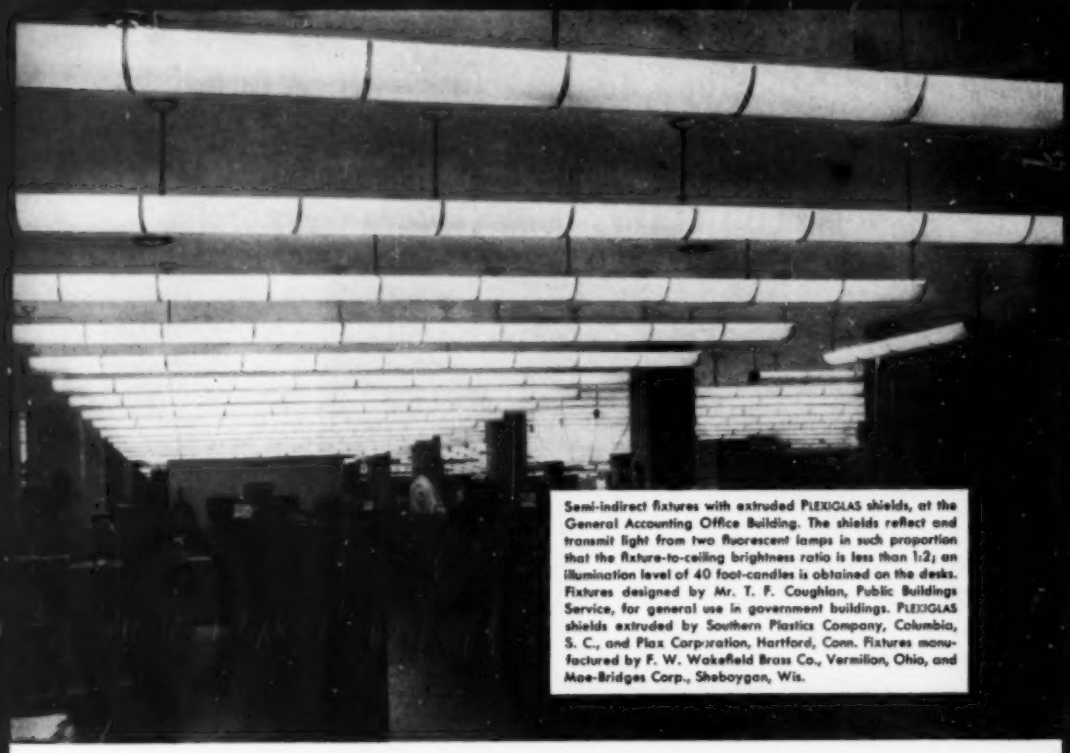

Semi-indirect fixtures with extruded PLEXIGLAS shields, at the General Accounting Office Building. The shields reflect and transmit light from two fluorescent lamps in such proportion that the fixture-to-ceiling brightness ratio is less than 1:2; an illumination level of 40 foot-candles is obtained on the desks. Fixtures designed by Mr. T. F. Coughlan, Public Buildings Service, for general use in government buildings. PLEXIGLAS shields extruded by Southern Plastics Company, Columbia, S. C., and Plax Corporation, Hartford, Conn. Fixtures manufactured by F. W. Wakefield Brass Co., Vermilion, Ohio, and Moe-Bridges Corp., Sheboygan, Wis.

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Nearly thirty-three thousand fluorescent fixtures, with twenty-five miles of translucent PLEXIGLAS shields, light the new General Accounting Office Building in Washington.

Extruded from PLEXIGLAS acrylic molding powder, the shields are important to the successful lighting of the building. They *reflect* light to the ceiling, to create large-area, low-brightness, indirect illumination. They also *transmit* the proper proportion of light needed to maintain a minimum brightness ratio between the luminaires and the ceiling.

From luminaires to luminous ceilings, white translucent PLEXIGLAS contributes to better lighting. Available in the form of flat or corrugated sheets, and as molded or extruded sections, this durable acrylic plastic provides uniform diffusion and efficient transmission of light—*plus* excellent color stability. In addition, the light weight and strength of PLEXIGLAS give freedom from breakage during installation and maintenance, and safety overhead in service. We will be glad to tell you how PLEXIGLAS can be used in your next lighting installation.

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PLEXIGLAS is a trade-mark, Reg. U. S. Pat. Off. and in principal foreign countries.

Canadian Distributor: Crystal Glass & Plastics, Ltd., 130 Queen's Quay at Jarvis Street, Toronto, Ontario, Canada.

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20% more light!

Yes, MITCHELL MODULE is *still* unequalled for effective light output, unequalled because inch for inch it delivers *more* light per operating dollar than any other louvered commercial fixture. MODULE'S exclusive Polystyrene plastic louver passes 20% MORE LIGHT than conventional metal louvers—saves more lighting dollars in *every* installation.

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And MITCHELL MODULE is *still* the *only* lighting system that *custom-fits any installation with standard low-cost units.* With just 4 simple, inexpensive "building blocks of light," MODULE creates *unlimited* custom-fitting lighting patterns. Because MODULE units fit together simply (both mechanically and electrically) patterns can be rearranged to meet changing needs—*at minimum cost.*

MODULE'S styling is enduring; stays beautiful, new. No ordinary fixtures can match MODULE—*still* the *only* lighting system that delivers *20% more light* and *custom-fits* any commercial interior at *lowest operating cost.*

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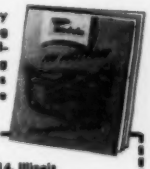

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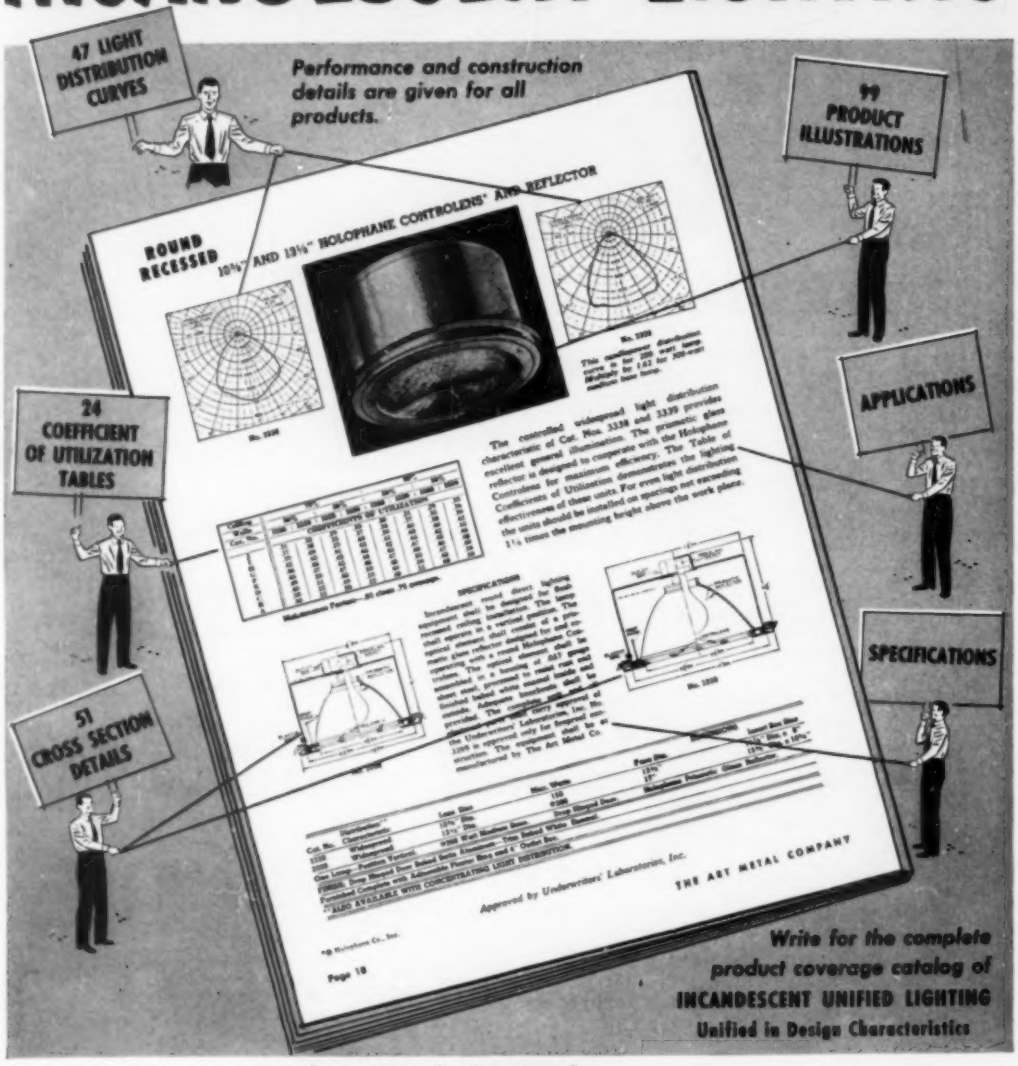

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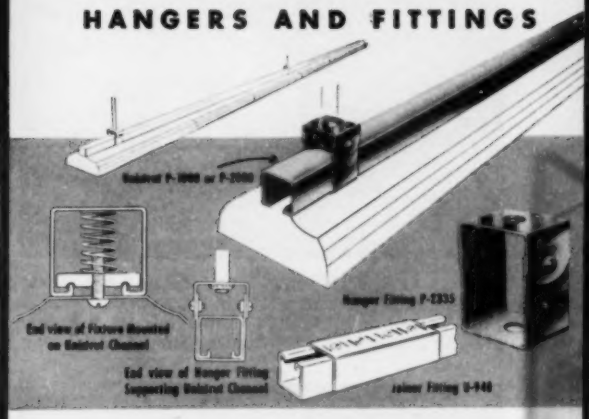
HANGERS AND FITTINGS

BEFORE VIEW of study hall of suburban High School, Jackson, Michigan. Approximately 49 ft. by 83 ft. with 20 ft. ceiling. Twenty one 6 ft. open glassware steel suspension fixtures with 4-200 watt lamps. Fixtures suspended 10 ft. above floor. Average illumination was 3 to 5 foot candles.

AFTER VIEW of same study hall showing 4-lamp 40-watt fluorescent fixtures in continuous rows completely supported with Unistrut P-2000 channel and suspended 13 ft. above floor with 1/2 in. conduit stems, canopies and Unistrut Hanger Fitting P-2335. Average maintained foot-candles is 35-40.


End view of Fixture Mounted on Unistrut Channel
End view of Hanger Fitting Supporting Unistrut Channel
Hanger Fitting P-2335

Lighting recommendations by and photographs courtesy of Consumers Power Company, Jackson, Michigan.

THE COMPLETELY MODERN METHOD of Hanging Fluorescent Fixtures gives you these Exclusive Advantages:

FEWER HANGER STEMS AND CANOPIES UNISTRUT'S great channel strength permits wider spacing of stems—up to 15 feet apart if desired—for better appearing installation and obvious savings.

PERFECT ALIGNMENT—UNISTRUT channel is rigid, strong and perfectly straight—gives you true alignment of fixtures. Cleaning, re-lamping, or other servicing cannot disturb this alignment.

COMPLETELY FLEXIBLE—Stems or rods can be installed at any point along UNISTRUT channel. Overcomes possible ceiling irregularities or obstructions. Ideal for continuous runs or intermittent spacing of fixtures.

FASTER, EASIER INSTALLATION—UNISTRUT channel and fittings are attached to fixtures quickly and easily at normal working height or at suspension level. No drilling, no welding, 100% adjustable.

ADDED SAFETY—UNISTRUT assures the utmost safety of installation because an entire row of fixtures becomes a single integrated unit—added safety obtained by no other method.

SAVES TIME AND MONEY—Reduces number of canopy and stem sets used, lowers wiring and rewiring costs, eliminates drilling and welding costs, saves planning and installation time.

UNISTRUT APPROVED AS WIREWAY—UNISTRUT channel has been approved as a wireway by the department of electrical inspection in Chicago and 20 major cities throughout the country ... additional proof of the versatility and all around practical usefulness of UNISTRUT.

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U. S. Patent Numbers
2327587 2329815 2345050
2363382 2360379 2405631
2541908 Other Patents Pending

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4 examples: G-E Light Conditioning program now underway in a BIG way!

FEATURED AT HOME BUILDERS' SHOW. Most of the 40,000 people at this year's Atlanta exhibition saw the Georgia Power Company's Light Conditioning demonstration . . . one of the show's outstanding attractions.

SEEN BY THOUSANDS OF CLEVELANDERS. This home, one of 8 sponsored by the Cleveland Electric Illuminating Company, stayed open day and night; attracted thousands of home buyers interested in Light Conditioning.

ATTRACTED MORE THAN 12,000 VISITORS. People in the Metropolitan New York area flocked to see this Light Conditioned house in Closter, N. J. Recipes used included valance lighting in living room and dining room.

PRODUCED REQUESTS FOR 5000 RECIPE BOOKLETS. After seeing Boston Edison's model Light Conditioned living room, guests of the New England Home Show requested over 5000 Light Conditioning booklets.

ALMOST 100 electric service companies have already begun to tie in with General Electric's Home Light-Conditioning Program. More and more lighting equipment suppliers are promoting Light-Conditioning.

Nearly 2 million Light-Conditioning recipe booklets have been distributed. And millions of people have been seeing and reading General Electric's national advertising on Light-Conditioning.

Shown above are four typical examples of how the Light-Conditioning Program is being carried on. To learn how you can tie in, call your G-E Lamp District Office, or write Lamp Division, General Electric, Dept. 166-IE-9, Nela Park, Cleveland 12, Ohio.

You can put your confidence in—

GENERAL ELECTRIC

(*Continued from page* 12A)

This book is based on a series of six lectures given for young people at the Royal Institution during the 1946 Christmas season. The author is Director of the Vision Research Unit of the Medical Research Council, London.

Chapter headings include The Properties of the Spectrum, How Colours are Produced, Colours and Their Uses, How Colours are Seen, Some Illusions of Colour, and Some Colours with Strange Properties.

Recent Advances in the Physiology of Vision by Hamilton Hartridge, published by The Blakiston Company, Philadelphia, 1950; 413 5 x 7¾ inch pages, 236 illustrations, 39 tables; $6.00.

Each chapter of this book is complete in itself with a description of older work and the recent advances clearly presented; at the end of many chapters are suggestions for future research. Over 300 references are cited. The author is Director of the Vision Research Unit at the Medical Research Council's Institute of Ophthalmology and Professor of Physics at Gresham College, London.

Topics treated include basic properties of vision (x-ray methods of investigating living human eyes, retinal receptors and their properties, the quantum theory of light and its connection with vision, the duplicity theory of vision, pigments associated with vision, light and dark adaptation, limits of the visible spectrum, eye movements, and blinking and visual efficiency), the perception of shape and size, investigations of retinal function, perception of color, theories of vision, neurology of vision, properties of structures of the eye, and appreciation of light and color.

Colour, published by the Dyestuffs Division, Imperial Chemical Industries Ltd., 1950; available in the U. S. from Arnold Hoffman Co., 55 Canal Street, Providence, R. I.; 120 8¼ x 11 inch pages, 69 illustrations; free.

This volume contains nine papers describing investigations in the fields of color physics and color psychology carried out in the laboratories of the Dyehouse Department of I.C.I. Dyestuffs Division at Blackley, Manchester, England from 1940 through 1948. The papers are as follows:

"Colour" by G. S. J. White and T. Vickerstaff, a broad survey including color of light source and object, color vision, and methods of specifying color.

"The Physical Significance of the Dyer's System of Colour Matching" by T. Vickerstaff, E. Winters and G. S. J. White.

"The Brightness of Present-day Dyes

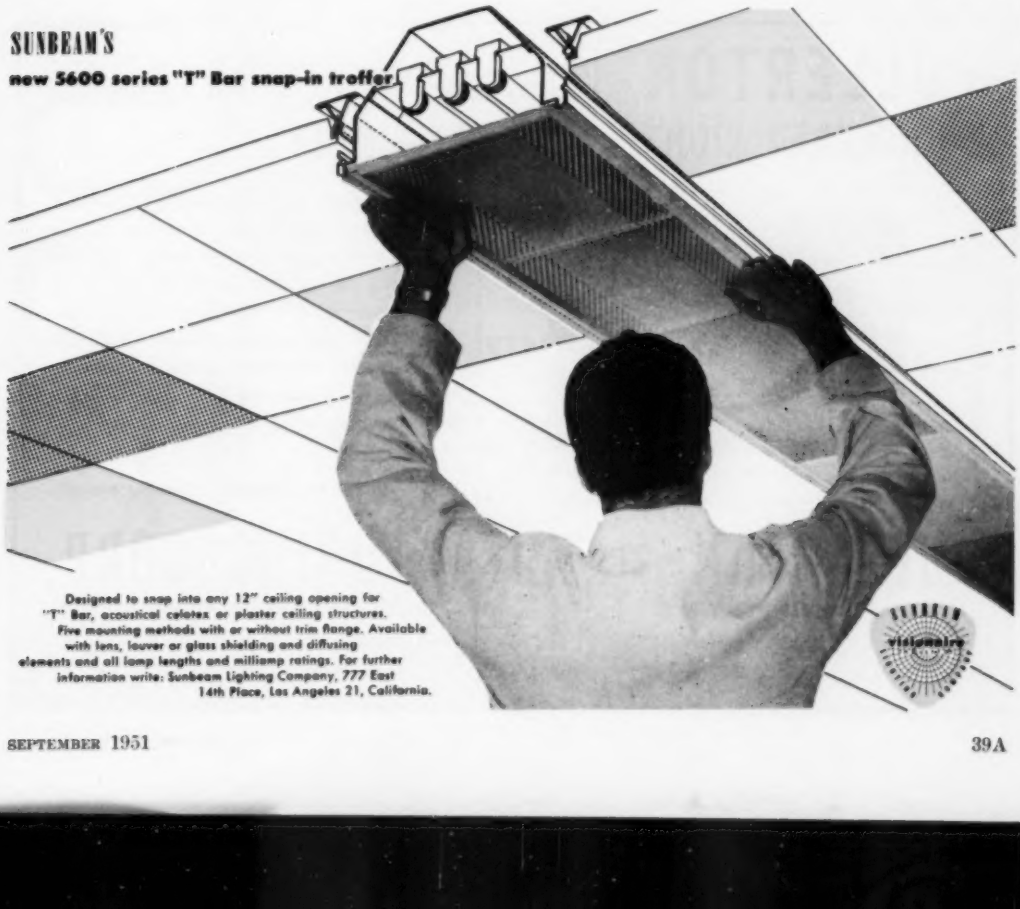
"The Brightness of Present-day Dyes" by T. Vickerstaff and "Brightness and Hue of Present-day Dyes in Relation to Colour Photography" by M. E. Clarkson and T. Vickerstaff, using the dyer's term *brightness* meaning a combination of *color* and *purity*.

"Investigation of the Legibility and Aesthetic Value of Coloured Printing Inks on Coloured Papers," by T. Vickerstaff and C. S. Woolvin, including a chart showing fourteen different colors of lettering each printed on ten different background colors.

"Colour Harmony," by M. E. Clarkson, O. L. Davies, and T. Vickerstaff, another paper giving the statistical results of an investigation of the aesthetics of color.

"The Estimation of Dyestuffs in Solution and on the Fibre," by E. Waters, a

(*Continued on page* 40A)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visionaire

(Continued from page 39A)

review of methods and apparatus for color measurements.

"The Accuracy of Colorimetric Instruments in Dye Strength Determinations" by O. L. Davies, G. H. Giles and T. Vickerstaff, a statistical survey of the accuracy obtainable by color measuring techniques.

"A Photoelectric Device for Recording Variations in the Concentration of a Coloured Solution" by T. B. Davenport.

Handbook of Human Engineering Data for Design Engineer, Technical Report SDC 199-1-1, prepared at Tufts College for the Office of Naval Research; 364 8½ x 11 inch pages in loose leaf binder; published 1949; available at $5.00 per copy from the Tufts College Bookstore, Medford, Massachusetts.

This volume supplies practical information on the practical limits of human performance and sensitivity which should be considered in engineering design. After an introductory section which explains the purpose of the studies and some of the procedures used to obtain the data, there follow chapters on the physical dimensions of the body and space requirements for functional use of the body, vision, hearing, skin sensitivity and proprioception (balance and control of position and movement of various parts of the body), motor responses, physiological conditions as determinants of efficiency, and intelligence.

The vision chapter (108 pages) deals with the basic characteristics of vision including light sensitivity as influenced by characteristics of the subject, the eye, the stimulus and physiological factors; brightness discrimination; visual acuity; depth perception; color vision; intermittent stimulation; perception of movement; factors influencing the efficiency of vision including illumination and effects of the atmosphere on long range visibility; and finally applications of visual data in predetermining the legibility of indicators and printed material. Bibliographies in this section list 372 related references.

Value of Good Lighting in War Production — A Survey of Opinion from a Cross-Section of American Industry — is a report issued by the Illuminating Engineering Society during World War II, which is again available from Society Headquarters. This 24-page booklet contains laboratory findings and field opinions on nine results of proper lighting in war production plants: accuracy of workmanship, less spoilage, faster seeing, greater ease of seeing, less eyestrain and fatigue, better utilization of floor space, easier plant maintenance, improved labor conditions, greater safety. The pamphlet is available from the Illuminating Engineering Society, 1860 Broadway, New York 23, N. Y.

An Introduction to Luminescence of Solids by Humboldt W. Leverenz, published by John Wiley & Sons, New York, 1950; 574 5¾ x 9 inch pages, 143 illustrations; price $12.00.

In the words of the author, "This book is designed to provide an introductory and useful description of luminescent solids, particularly artificial (man-made) phosphors, in language comprehensible to science graduates. Much of the material is drawn from personal experience in synthesizing, studying, and applying luminescent solids since 1931, that is, during the recent era of intensive phosphor research which made possible such

(Continued on page 42A)

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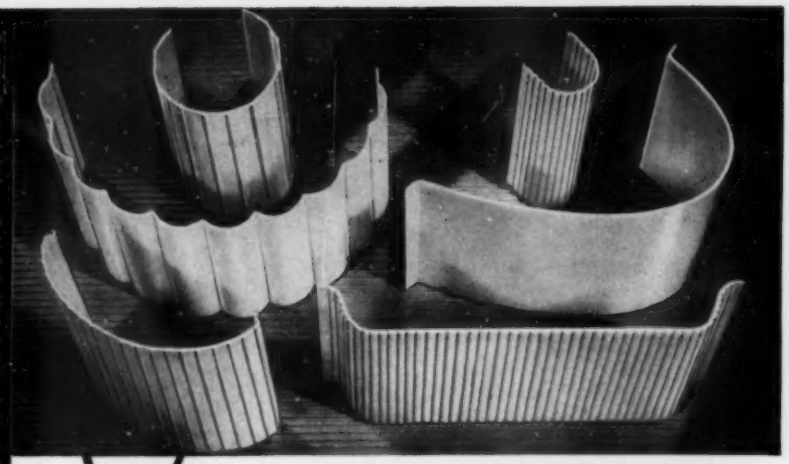

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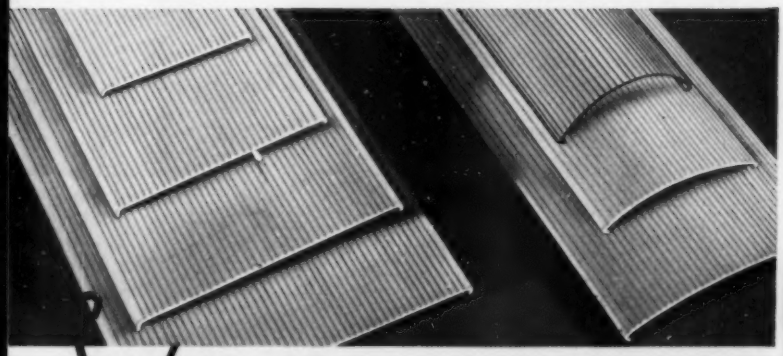

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(Continued from page 40A)

modern developments as electronic television, fluorescent lighting, radar, electron microscopy, and devices for seeing many otherwise invisible forms of energy. Although the book is intended for nonspecialists in luminescence, it is expected that it will be useful as a text in training future specialists and in aiding scientists who wish (a) to refresh and increase their knowledge of solid matter and its interactions with radiations and charged material particles, and (b) to use phosphors for detecting radiation and material particles."

The first two chapters deal with elementary concepts of the structure of matter and properties of crystals. These are followed by three chapters, the bulk of the book, on the synthesis of phosphors; constitutions, structures, and energy levels of phosphors; and phosphor luminescence, including excitation, energy transformation, storage and emission processes, analysis by means of luminescence, luminescence as a function of time, stimulation and quenching of phosphorescence, and luminous efficiency of phosphors. The remainder of the volume deals with the general properties of phosphors and their uses (with a seven-page highly technical treatment of phosphors in fluorescent lamps). Other features include appendices on the preparation of pure zinc and cadmium sulfides and zinc selenide, proportions of impurity atoms, conversion tables for units, and spectral characteristics of luminescence; glossary; 750 references; and three indices—formulas, proper names, and subjects.

Modern Fluorescent Lighting by A. D. S. Atkinson, published by George Newnes, Ltd., London, 1951; 159 5¼ x 8½ inch pages, 64 illustrations; price 15s (approx. $2.10) in England.

This is an almost completely rewritten version of the author's 1946 *Fluorescent Lighting*. Topics treated include auxiliary devices and circuits for standard (hot-cathode) British lamps and their operating characteristics; installation design; performance of various modern types of fluorescent luminaires; guides to the application of fluorescent lighting equipment in factories, stores, schools, offices and homes (all based upon the British recommended levels of illumination which, for economic reasons, are lower than those considered good current practice in the U. S.); brief treatments entitled "fluorescent versus filament lighting" and "cold cathode tubes"; with a final chapter on light, fluorescence and electric discharge. Appendices present room index and coefficient of utilization tables and data on standard English lamps and auxiliary equipment.

The author credits three sources for most of the information presented: the British Electric Lamp Manufacturers' Association and the publications of the British and American Illuminating Engineering Societies. Many of the photographs were supplied by the U. S. General Electric Company.

Gas Discharge Lamps by J. Funke and P. J. Oranje, published by N. V. Philips' Gloeilampenfabrieken, Eindhoven, Netherlands, 1951; 288, 6 x 9¼ inch pages, 110 tables and graphs, 82 photos; price $4.50.

As stated by the authors, the purpose of this book is to present, in simple terms, a survey of existing types of discharge lamps, together with their relative possibilities, advantages and disadvantages, characteristics and principles. All the equipment described is manufactured by the Philips Company but most of the discussion applies to

your assurance of ACCURATE luminaire design—
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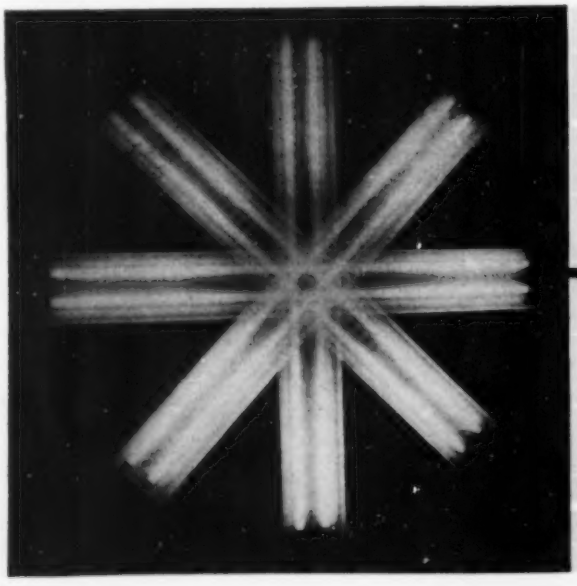

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other lamps as well. Chapter headings include: gas discharge lamps, auxiliary apparatus, the relation between gas discharge lamps and their auxiliary equipment, sodium lamps, high pressure and super-high pressure mercury vapor lamps with forced cooling or very high specific load, low pressure tubular fluorescent lamps, gas discharge lamps for beaconing and luminous advertising, stroboscopic lamps and flash tubes. The volume is concluded by a series of data sheets on Philips gaseous discharge lamps and a bibliography of related papers written by members of the Philips organization.

Dutch, French and German language editions of this work were published previously. The English edition is available in the U.S.A. from the Elsevier Publishing Co., 250 Fifth Avenue, New York City.

Electric Illumination Handbook No. 7: Industrial Lighting — published by the Lighting Service Bureau, 2 Savoy Hill, London, 1951; 68 5½ x 8¾ inch pages, 28 photographs.

The objective of this British booklet is "to indicate the factors which should be taken into account in considering the lighting of industrial premises." The fundamental design considerations, which compose the main part of the publication, are excellently presented, but owing to economic factors the levels of illumination listed are somewhat lower than those currently recommended in the United States.

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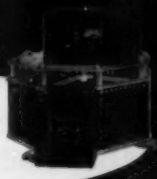

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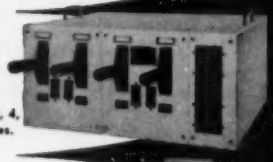
available in manually-operated and motor-driven models in capacities from 1,000 to 30,000 watts.



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2. **Utility Lighting and Power Representatives**
3. **Electrical Distributors' Specialists and Salesmen**
4. **Architects and Consulting Engineers**
5. **Owners and Users of Industrial and Commercial Lighting**

Judging will be intra-group—that is, an entry by an electrical contractor will compete with only those of other electrical contractors. When the installation is the cooperative work of men in two or more of the above classifications, the entries may be submitted as a joint entry and entered in one or more of the applicable classifications.

Only installations made between July 1, 1950 and December 31, 1951 are eligible for awards.

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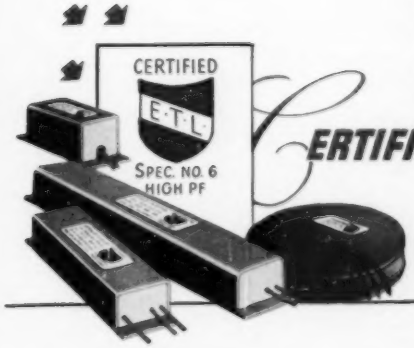

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